FINAL REPORT

DEMONSTRATION OF IMPROVED VEGETABLE PRODUCTION TECHNIQUES FOR SASKATCHEWAN

19960356

April 2000

Prepared by: Saskatchewan Irrigation Diversification Centre

AGRI-FOOD INNOVATION FUND

Canada

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Irrigation
Diversification
Centre

Demonstration of Improved Vegetable Production Techniques for Saskatchewan

Project #96000356

AGRI-FOOD INNOVATION FUND

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CANADA SASKATCHEWAN IRRIGATION DIVERSIFICATION CENTRE
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ICDC
Irrigation Crop Diversification Corporation

Saskatchewan

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APRIL 2000

1. SUMMARY

At 7% "in-season" self sufficiency, Saskatchewan imports about $20,000,000 of fresh vegetables annually. To further exploit this apparent diversification opportunity a vegetable project was initiated in 1996 to demonstrate newer production technologies and to obtain data for Saskatchewan based costs of production. One half acre sized fields of pumpkin, carrots, cabbage, cucumber and pepper have been grown and marketed to simulate commercial production. The results have shown that acceptable yields of suitable quality produce can be grown and superior quality where proximity to market is a factor. Net returns have been positive for the most part but, since labour is such a significant component of variable costs, productivity and efficient use of labour can be critical. These initiatives have given the vegetable industry in Saskatchewan further impetus and direction. A number of new producers and a new generation cooperative, currently in the formative stages, appear poised to further diversify the agricultural landscape with **SASK GROWN** fresh vegetables.

2. TECHNICAL REPORT

2a) Project Objectives

1) To demonstrate aspects of production, post harvest handling and marketing of selected vegetable crops.
2) To develop cost of production information for some of the commonly grown vegetables, to determine break-even costs for the rationalization of purchase of equipment and to evaluate long term economic sustainability.
3) To demonstrate the efficiency of drip irrigation and other technologies such as plastic mulches, mini-tunnels and floating row covers for producing high value vegetable crops.
4) To compare yield potential and quality characteristics for selected vegetables grown under irrigated and dry land conditions.

2b) Project Activities

Selected varieties of pepper, pumpkin, cucumber, cabbage and carrots were grown on approximately ½ acre plots each year over a three year period to simulate commercial production. The resulting crops were harvested, washed, graded, packaged as appropriate and marketed to wholesale buyers. Data obtained was used to calculate a Saskatchewan based cost of production for each crop.

Drip and wheel move irrigation technology was demonstrated in this project. Surface and subsurface drip irrigation technology gave way to the use of surface drip irrigation exclusively as the project progressed. Irrigation scheduling utilized tensiometers and / or watermark sensors placed below and to the side of rows.

Wind protection was provided for the pumpkin, cucumbers and peppers by means of rye solid seeded between the mulch rows either the fall prior to production or early in the spring. It was subsequently removed in mid summer.

Field days and tours were held to demonstrate production techniques to interested individuals. In addition wholesale buyers were invited to similar events to view the quality of the resulting crops and begin the process of encouraging the use of **SASK GROWN** produce.

A) PEPPERS

The varieties Ultraset and Valencia were grown as transplants utilizing IRT (infrared transmissible) mulch and mini-tunnels.. The peppers were started in the greenhouse in early April and field planted the end of May in a double row configuration on each mulch row. Peppers were planted 12" apart towards the outer edge of the mulch. Floating row covers were used along with mini-tunnels the first year of the project but abandoned in favor of the mini-tunnels in subsequent years. These were put in place soon after planting and removed shortly before blooming in latter June or early July

Drip irrigation tubing situated immediately under the IRT mulch and centered between the two plant rows was used to supply water.

Peppers were harvested as mature red bell peppers where possible but also as mature green peppers. They were placed in storage then graded and packed in 25 pound boxes for shipment. Peppers not meeting consumer grade were packed and sold for the chopper market. Peppers remaining at the end of the season one year were harvested prior to a killing frost, cut, diced, blanched, packaged, frozen and sold in six 2 kg packages per box as frozen diced peppers for processing.

B) PUMPKIN

Spirit pumpkin was seeded under IRT mulch towards the end of May in each of the three years. A hand planter was used initially but subsequently the water wheel transplanter without water was used. Planting on IRT mulch left in place from the previous year was abandoned in favor of new mulch each year since mice surviving under the mulch over winter chewed the seed prior to germination. In row spacing was 36" using a double row configuration about 24" apart on each mulch row.

Initial trials with surface and subsurface drip irrigation were abandoned in favor of surface drip irrigation. The drip tape was located just under the IRT mulch equidistant between the 2 rows.

Bee colonies were located in the area for pollination.

The pumpkins were cut with stems left attached then picked using a picking aid and placed in bulk bins for storage. From storage most were graded and repacked in bulk bins for shipment although some were packed in 50 pound sacks.

C) CUCUMBER

Slicing cucumber, hybrid variety Jazzer, was grown from seed on IRT mulch with an in-row spacing of 24". A double row configuration on the mulch was used. Initial use of a hand planter for seeding gave way to the use of the waterwheel planter without water. Initial use of one seed changed to the use of 2-3 seeds per hole to better ensure an adequate stand.

Growing cucumbers on year old mulch was abandoned in favor of new mulch each year.

Initial trials with surface and subsurface drip irrigation were abandoned in favor of surface drip irrigation. The drip tape was located just under the IRT mulch between the 2 rows.

Bees were used to ensure pollination.

Cucumbers were hand harvested into bulk tubs, stored then graded and packed by count either 24 or 36 per case.

D) CABBAGE

Initially production from direct seeded Lennox cabbage was compared to that from transplants started in the greenhouse. In the last year of the project

transplants were used exclusively. The cabbage was grown spaced 18" in-row and 24" between rows. Transplants were started mid April and field planted mid to latter May. Direct seeding with a Stanhay precision planter was undertaken in mid May.

Spraying for flea beetles, root maggots and the imported cabbage butterfly was done as needed.

A wheel line sprinkler system was used to supply irrigation water.

Some cabbages were packed in 50 pound sacks for retail shipment but most were bulk packed in pallet bins for processing.

E) CARROT

Pelleted seed of the Imperator carrot variety Carobest was direct seeded with a Stanhay Precision seeder. These were seeded onto raised beds in mid May at the rate of 30 to 36 seeds per foot of row. Rows were spaced 24" apart. In the last year of the project the carrots had to be reseeded as a result of poor germination.

Linuron and/or trifluralin were used for weed control. Irrigation was accomplished with a wheel move sprinkler system although in the first year a subsurface drip system was used.

Carrots were hand harvested and washed since commercial scale equipment was not available. While some were harvested early as bunching carrots most were harvested as storage carrots in mid October. These were packed in 2 or 5 pound consumer packs in bales of 24 X 2 or 10 X 5. Oversized and usable cull carrots where bulk packed in 50 pound bales for processing.

2c) Project Results and Conclusions

The three years of this project have provided a wide range of growing conditions. The year to year variations in terms of cumulative corn heat units are shown graphically in Appendix A. The first year of the project was near average at 2369 while the second year was much above at 2545 and the last year much lower at 2077 cumulative corn heat units. The long term average is 2253. The heat loving crops pumpkin, cucumbers and peppers performed exceptionally well the second year while the cabbage, being a cool season crop, performed much better the third year.

A) PUMPKIN

Pumpkin has produced the most impressive results. Yields ranging from 38.7 to 63.5 tons per acre were achieved. Average prices ranged from 13 to 15 cents per pound on a year to year basis. The average price over the three year period was 14.5 cents per pound. Bulk pumpkin ranged from a low of 11 cents per pound to 18 cents for bagged pumpkin. To cover extra costs for labour, bags, tags and extra weight bagged pumpkin should be a minimum of 4 cents per pound over the bulk price to obtain the same return.

The quality of the pumpkin grown was excellent and well received. Most were completely orange in the field. Some later pollinated pumpkin required further ripening in the greenhouse but there was little loss due to green colour. Some rot from sclerotinia was experienced but kept to a minimum with adequate rotations.

The net returns were positive each year ranging from a low of $2964/ac in the last year of the project to a high of $8772 in the second year.. These results have encouraged a number of private operations to grow pumpkin. Since there is a

limited market for pumpkins and it is also very seasonal interested growers should have a market established prior to planting and exercise caution.

B) PEPPERS

Pepper returns have been the most variable and obviously are very weather dependent. Total heat units not only affected yield but quality as well in terms of sizing and the volume of red peppers produced. The last year of the project was the only year there were no red peppers. Overall marketed yields ranged from a low of 300 lbs /ac in the last year of the project to a high of 43667 lbs /ac in the second year. Similarly the gross returns ranged from $139 to $23808 / ac

The average yield over the 3 year project was 22490 lbs /ac with an average gross return of $10166/ ac or $0.452 / pound. Net returns averaged $1818/ ac on the basis of assumed efficiencies

Peppers are sold on the basis of size and color. Those not sufficiently sized can be sold as a chopper grade for restaurants and institutions. Red peppers command a premium. The prices received for the respective grades are as follows:

Table 1 Pepper Prices Relative to Size and Color

Year $ / lb	Green retail	Green choppers	Red retail	Red choppers
1997	$0.414	$0.327		$0.756
1998	$0.594	$0.360	$1.180	$0.790
1999		$0.460		

Most peppers were sold in a 25 pound pack although some did move in a 5 kg pack

Results comparing the use of mini-tunnels with row covers indicated higher yields were achieved with mini-tunnels. Based on one years data with Valencia, row covers produced the equivalent of 43270 lbs/ac, mini-tunnels 46264 lbs/ac and no covers 28060 lbs /ac.

Row covers were difficult to hold in place since they had to be above the crop canopy to avoid abrasion damage. They were consequently more exposed to wind. At a cost of $2419 /acre for row covering it would have to be reusable for at least 4 –5 years to be cost competitive with mini-tunnels at $501 /acre plus hoop wire at $411. Hoop wire should be reusable for a number of years. Labour costs for installation were higher for the floating row cover as well and could be more significant if wind damage occurred.

Mini-tunnels, however , have a limited potential to prevent frost damage. The threat of frost was not a factor in this project during spring planting and the peppers were harvested immediately prior to any potentially killing fall frost. The use of floating row covers for frost protection is a management decision which is worthy of serious consideration particularly for extending the harvest period where or when earlier fall frosts may occur.

The Valencia variety proved to have a most acceptable shape and size for the green retail market but poor red colour while the Ultraset had an excellent red colour but poor shape and size for the green pepper market.

The option to make diced frozen peppers from produce picked immediately prior to freeze up explored in the latter two years of the project

indicated that an acceptable product could be achieved but that the costs were too high. Efficiencies of scale and some degree of mechanization particularly with respect to the initial cutting would be required in order to make it economically viable. In addition some method of drying and/or freezing resulting in a loose frozen product would be required.

C) CUCUMBER – SLICING

Cucumbers are a labour demanding crop requiring careful picking every two days during the peak picking period. Moving vines too aggressively during harvest resulted in abrasion damage to young undeveloped fruit. This later resulted in scarring. These fruit were subsequently not saleable. A solution involved leaving the vines relatively intact while searching for harvestable fruit and removing those cucumbers with the least amount of vine disturbance. Utilizing this procedure increased labour costs but was necessary to achieve a marketable product. Other solutions not explored in this project would involve once over harvesting and/or the use of spineless varieties.

Accordingly high harvest costs resulted in this crop being the least attractive in the project on the basis of net returns. As noted above the grade out due to scarring early in the project was higher which contributed to a lower gross return. Temporary surpluses and competition from backyard gardens also reduced sale options on occasions. These losses ranged from 20 to 36% of marketed yields.

Marketed yields ranged from a low of 968 cases (24 count/case) as a result of lower heat units in the last year of the project to a high of 2347 cases / acre with an average yield of 1864 cases / acre. The gross dollar return ranged from $5041 to $12705 / ac averaging $10105 / ac over the three year period. Net returns were negative $1578 to $3011 per acre or $1377 /acre average.

Further mechanization in terms of picking aids as well as improved packaging efficiencies would significantly improve the economics of cucumber production.

D) CARROTS

In terms of ease of production, quality, yield and market demand carrots are probably the most attractive option in this project for further development. They are one of the few vegetables that can be entirely mechanized. They are, however, demanding in terms of storage requirements particularly long term storage.

Bunched carrots (6 to 8 per bunch X 24 / case) returned the equivalent of 704 cases valued at $8342 /acre the one year it was attempted. These carrots were somewhat small. Some additional growth would have consequently improved quality and gross returns.

Topped carrot yields ranged from a low of 8.7 tons / acre in 1999 to a high of 25.5 tons / acre in the first year of the project. The average yield over the three year project was 18.1 tons / acre. The higher yield would be more indicative of carrot potential. The crop in the final year had to be reseeded due to a germination problem. This crop did not get started until about a month after the normal seeding date and consequently did not have sufficient time to size.

Of the total marketable crop, an average of 78.3% was sold as a Canada No.1 product either in a 2 or 5 pound poly consumer pack while the remaining 21.7% was moved into the processing market.

The gross returns averaged $7628 / acre but a more realistic $9360 /acre if the last year of production was disregarded. The gross return varied from $4162 to $9888 /acre for the best year. The average price ranged from a low of $0.176 / lb in the early years of the project to a high of $0.238 / lb the last year (average $0.204/lb) while the average price received for the processing carrots was $0.157 and ranged from $0.153 to $0.16 /lb.

The scale of this project did not lend itself to efficiencies in harvest nor the washing, grading and packaging operation. The actual costs did not as a consequence result in a positive net return but assuming machine harvest and a reasonable washing, grading and packaging line along with good storage then it would appear that net returns in the range of $2500 to $3000 / acre could be achieved.

E) CABBAGE

Comparison of direct seeded cabbage to transplant production in the first two years of the project gave way to the use of transplants exclusively in the last year. Based on the costs obtained in this project, transplant production would result in a net increase in costs of $730 / acre for labour and $ 37 /acre for capital or a total of $807 / acre. Based on two years of data the average yield of the transplanted production was 27.9 tons/ acre while the direct seeded yield was 8.1 tons /acre. This net increase in yield was 19.8 tons /acre. At an average selling price of $0.112 / lb received the net return for transplants was $4430 /acre which more than covered the additional expense.

This increase in yield was attributed to more uniform and dense heads throughout the field. In addition transplanted cabbage were harvested about 10 days earlier than direct seeded cabbage.

Flea beetles, root maggots and imported cabbage worm were prevalent which required spraying on a regular basis. In spite of a reasonable spraying schedule the direct seeded cabbage likely suffered more than transplants further encouraging the use of transplants.

The average yield from transplants over the three years of the project was 32.0 tons / acre. With an average price of $0.112 the gross returns were $7153 / acre. The net return averaged $1562 /acre and ranged from $1065 to $2268 / acre.

COST OF PRODUCTION

Cost and return data are attached in Appendix B. The results for each year are provided along with an average for the three year period. These costs of production are based on actual experience but where operations were undertaken which would not be realistic in a commercial operation those costs are adjusted to more accurately reflect a more realistic set of data. Where actual fixed capital costs were not available these were calculated using cost estimates from other similar data or calculated on the basis of realistic estimates from industry participants.

The projected cost of production for each crop reflects an estimation of what a commercial operation should reasonably expect in terms of returns and costs. If yields or costs were abnormally high or low for a given year then those were adjusted in the projections to more accurately reflect a more normal set of circumstances.

The data indicates that pumpkin production provides the best net return of the crops grown in this project. Since the market for pumpkin is very seasonal and

limited, persons interested in pursuing this crop would be well advised to do so with caution.

Carrots followed closely by cabbage would present the next best alternative on the basis of the results. Both of these crops have the advantage of good volume requirements over the entire year. While the production of carrots is attractive, costs associated with proper storage requirements particularly for long term storage and marketing present an obstacle. Since carrots are one of the most exacting in their storage requirements, a filacel storage is required for long term marketing although refrigerated storage with humidity controls would be usable for short term marketing.

Cabbage are less exacting and could be stored under refrigeration with proper humidity controls. A tendency for cabbage to loose colour with length of storage may require the introduction of new varieties and/or improved storage technology such as controlled atmosphere storage.

The next attractive crop would be peppers. This crop is dependent on warmer weather more than any of the other crops grown in this project. While more experience is required it would be reasonable to assume that one or more years out of ten may result in reduced or no production and consequently significant negative results. On the other hand one or more years warmer than normal may result in gross and net returns significantly greater than any other of the crops in this project. Accordingly caution is advised until longer term experience can be accumulated. The option to profitably process peppers into a diced frozen product during or at the end of the season would ameliorate this conclusion significantly.

Labour cost associated with cucumber harvesting made this crop the least attractive in the project. The challenge to grow slicing cucumbers commercially is to devise a harvesting procedure or system that would reduce this cost or accept these results as a return to labour as opposed to a return to management. Marketing presents a further challenge for this crop in terms of dealing with short term surpluses although they could be accepted as a normal aspect of cucumber production.

DRIP IRRIGATION

The results comparing surface to subsurface drip irrigation did not seem to indicate any advantage in terms of yield or quality in favor of one or the other. The installation and additional management factors would seem to indicate a preference for surface drip irrigation from a commercial production perspective although the long term aspect of subsurface drip irrigation was not fully explored in this project.

Drip irrigation did appear to contribute to higher crop yields, improved crop quality and better uniformity. Reduced weed competition and continuing harvest operations while irrigating were added benefits. The ability to add fertilizer on a continuous basis with drip irrigation presents a further potential advantage but will require additional research on a crop by crop basis.

LABOUR

The most significant cost associated with vegetable production in this project was labour. As a percentage of variable costs labour ranged from a low of 25.2% for pumpkin in the first year to a high of 59.8% for cucumber in the second

year. Based on averages the pumpkin required the least amount of labour at 33.2% while the production of cucumber required the most at 51.7% of variable costs.

Table 2 Labour Costs as a Percentage of Total Variable Costs

	cabbage			carrot			Pumpkin		
Year	1997	1998	1999	1997	1998	1999	1997	1998	1999
greenhouse	4.3	13.2	1.8						
Preharvest	13.3	19.6	17.8	4.1	4.9	4.4	9.4	14.5	6.2
Harvest	30.9	15.4	18.1	4.0	4.8	14.0	9.5	12.5	15.3
Post harvest	W/above	0.4	4.4	33.0	39.3	36.6	6.3	2.1	23.8
total	48.4	48.5	42.1	41.1	48.9	55.0	25.2	29.0	45.3

	pepper			cucumber			Average		
Year	1997	1998	1999	1997	1998	1999	cabbage	46.3	
greenhouse	2.2	2.6	1.8				carrot	48.3	
Preharvest	14.9	8.5	35.7	7.1	5.1	13.7	pumpkin	33.2	
Harvest	10.1	22.2	18.0	26.5	39.0	21.5	pepper	42.4	
Post harvest	4.4	6.6	0.2	13.3	15.6	13.4	cucumber	51.7	
total	31.7	39.9	55.7	46.9	59.8	48.5			

The development of mechanization and efficient operating systems to reduce as much labour inputs as possible is the first most important requirement to improve the bottom line for commercial operations. Secondly managing human resources to assure efficient use of labour and that employees are trained and motivated to perform efficiently is equally important.

2d) Further Development

1) Continued applied research and demonstration of selected vegetable crops is needed to create a focal point for continued interest in the vegetable industry and provide information on production related concerns.

2) The information gathered from this project has and will continue to provide a basis for private individuals to engage in vegetable production and marketing from their own farms. The success or failure of those individuals and groups will depend on their ability to make sound management decisions both individually and collectively.

Greater success will be achieved by supporting and more importantly encouraging those individuals / groups as they pursue their objectives. Consequently some degree of one on one management consultation should be provided for a period of time to monitor these operations from a management and financial perspective. Ideally this would involve an individual with access to marketing, management, accounting and legal resources as needed. The emphasis should be on eliminating business downturns before they occur.

Encouragement should be achieved through recognition of those individuals by their peers as well as by the provincial government and its departments.

3) Plant populations needed to achieve maximum yields and quality are largely unknown. Land costs are relatively inexpensive but labour is a significant cost factor. Larger areas to weed and harvest could represent higher costs. Some means of evaluating plant populations as it pertains to maximum yields of suitable quality vegetables would be appropriate to ensure efficient use of human and other resources.

4) Since labour is the most costly budget item, some emphasis on the labour component in designing operating systems, selecting suitable employees, motivating employees and rewarding productivity should be addressed on the job and in management training seminars.

Continued emphasis must be placed on Saskatchewan joining the rest of Canada in allowing the use of immigrant labour. This current restriction places Saskatchewan at an economic disadvantage since locally produced vegetables with higher labour costs per unit must compete with those from Alberta and Manitoba produced using migrant labour at a lower cost per unit. The wage rate is not lower for migrant labour, in fact it may be higher but the difference is in efficiency. The use of migrant labour at least in part is giving those producers in other provinces that efficiency.

5) Further work is required in relation to drip technology. There is a lack of information with respect to rooting depths of different vegetable crops under different growing conditions in Saskatchewan. Consumptive water use particularly as it relates to the use of different mulches is largely unknown. Determining soil moisture levels easier, more quickly and more reliably would assist in the efficient use of water and avoid yield and / or quality problems which occurs with over watering.

As well the use of drip irrigation allows for fertigation which will require a whole new set of guidelines on kinds, rates and timing to achieve the most economical yield.

Operating a drip system is much more management intensive which will require protocols to maintain system efficiencies and distribution uniformity. Initially owner / operator training should be the first line of defense but as more systems are put into operation a public or private evaluation 'service' to ensure continued operating efficiencies should be encouraged

6) Since quality is a prime consideration for wholesale buyers and slicing cucumbers are particularly prone to scarring during harvest, consideration should be given to the economics of once over harvests.

Further, the highest cost associated with cucumber production is labour and involves work least appealing to employees. The potential to mechanically harvest in a once over harvest may also improve net returns. Sequential planting to provide continuous market access would become crucial.

7)Post harvest physiology studies of carrots to determine maximum storability with the new filacel storage will be required to support marketing for an extended period of time.

Longer term storage of cabbage is possible with the use of controlled atmosphere (CA) storage and should be evaluated to determine colour retention potential and extended marketing possibilities.

2e) Information Sharing

Annual field tours along with private industry tours provided an opportunity for individuals to view production practices and crops as they were growing. An annual wholesalers tour also provided an opportunity for buyers to view the quality of **SASK GROWN** vegetables and provided an avenue for growers and buyers to meet and exchange information.

Media coverage including TV, radio and print further provided information to the public.

Annual industry meetings as well as special meetings over the three year period provided an avenue to dispense the results of the project in greater detail as well as provided feedback to the development of the project.

Private one on one meetings and discussions answered specific inquires from individuals.

2f) Project Success

The project success is most dramatically expressed by the fact individuals not previously in the industry have embarked on private production and marketing of vegetables from their own farms.

Further developments has seen the establishment of a Saskatchewan based organization, currently in the formative stages, dedicated to the cooperative marketing of vegetables from Saskatchewan farms.

The project itself has demonstrated that on average the quality of vegetables produced is as good as those produced elsewhere and better for some crops as a result of proximity to market.

Utilization of drip irrigation technology along with the use of mulch and mini tunnels where appropriate has demonstrated that above average yields are achievable. Produce resulting from the use of such technology appears to be more uniform allowing a larger percentage of the crop to be marketed. Drip irrigation as well has proven its advantage in reducing the weed load usually experienced with sprinkler or flood irrigation and has allowed harvest activities to continue uninterrupted often while irrigation is ongoing.

2g) Outputs and Deliverables

1) Cost of production and analysis for each crop has been provided.

2) Drip irrigation along with the use of mulch and mini-tunnels has been successfully demonstrated.

3) The use of floating row covers for frost protection has also been shown to be useful.

4) Initial development of a Saskatchewan based program to mark and identify **SASK GROWN** vegetables will in time and appropriate promotion increase awareness and provide consumers with an opportunity to select locally grown vegetables.

3. PERSONNEL

Laurie Tollefson
Barry Vestre
Harvey Clark
Natasha Stadnyk
Oliver Green

4. EQUIPMENT

No equipment purchased.

5. PROJECT PHOTOS

Slides and digital photos have been taken of appropriate activities throughout the three year project to provide a visual presentation of vegetable production. Those are archived for future reference and presentations as needed.

6. INNOVATION FUND ACKNOWLEDGMENTS

Agri Food Innovation Fund involvement in the project has been acknowledged in all signage, print material and verbally in tours and presentations about the project. In addition media interviews included reference to AFIF.

7. PROJECT INFORMATION MATERIALS

A brochure outlining the results of the project along with cost of production information has been prepared for distribution to interested individuals. A copy of the handout is attached. The results of the project have also been included in the CSIDC Annual Report. A presentation was made at the Soils and Crops Workshop in Saskatoon on February 24 and 25, 2000. A copy of the presentation to be included in the proceedings is attached. Results were also presented at a meeting of vegetable growers in Nipawin on March 10, 2000 and at the Saskatchewan Vegetable Growers Association annual meeting and workshop in Outlook, March 16 and 17, 2000 (agenda attached). A presentation was also made at the PFRA Symposium in Regina February 29 to March 2, 2000.

8. EXPENSE STATEMENT

Attached

AGRI-FOOD INNOVATION FUND

Canada Saskatchewan

Expense Claim
for Final Report

Project Number: 96000356 **Date: March 31, 2000**

Project Name: Vegetable Production Techniques

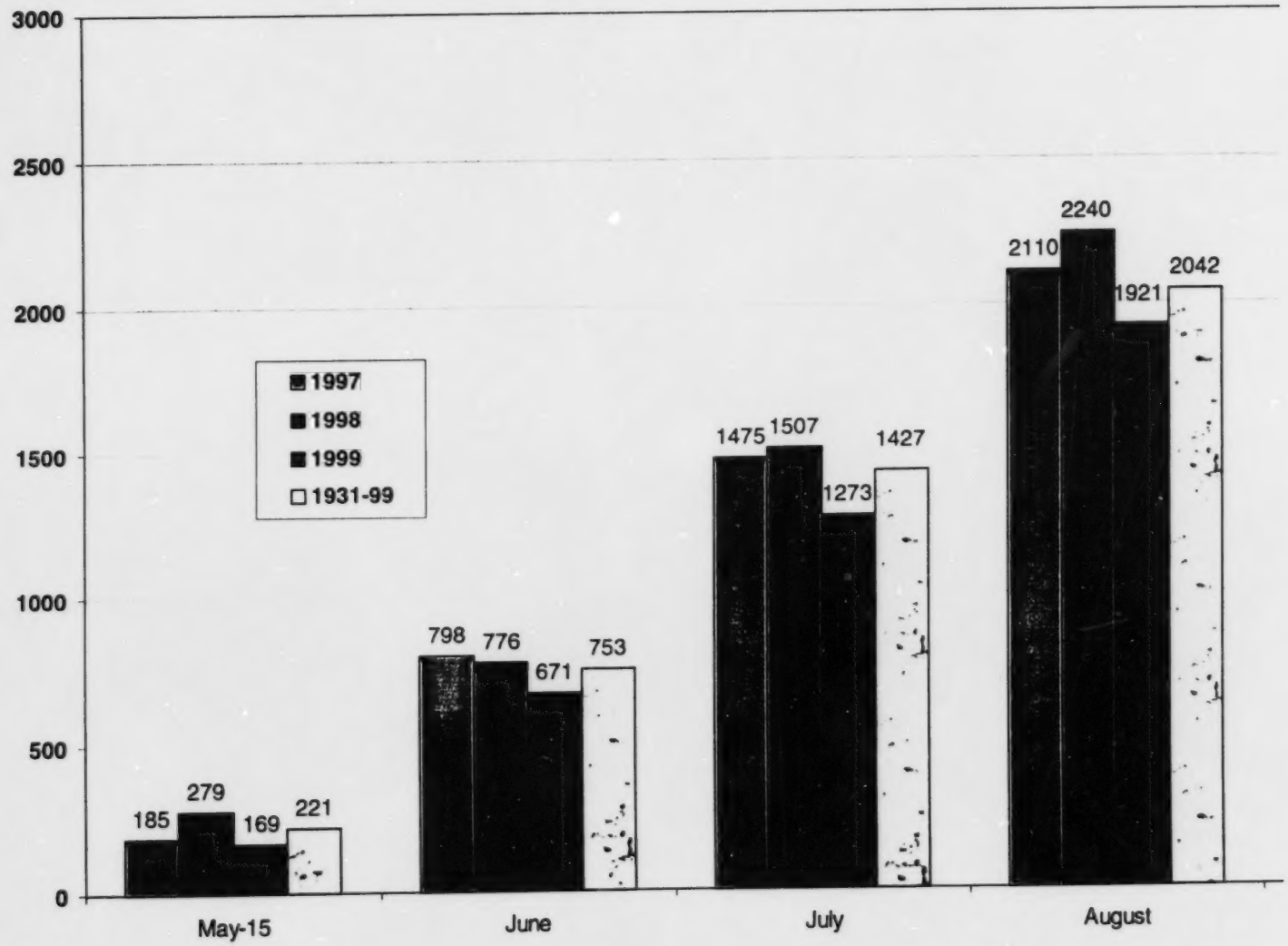
Contact Person: B. Vestre

EXPENDITURES	PROGRESS REPORT* Expenditures to end of reporting period: April 1/1999 - March 31, 2000
Salaries - Professional	
Salaries - Technical	$22,000.00
Salaries - Students - Temporary help	
Fees - e.g. Consultants	$8,400.00
Rental Costs	$239.90
Repairs - Equipment/Refrigeration	
Materials, Supplies	$2690.19
Project Travel	
Other - Telephone - Advertising - Freight	$125.21 $33.55 $14.13
TOTAL	$33,488.85
IN KIND	$28,000.00

Appendix A

Corn Heat Units, 1997 to 1999

Cumulative Corn Heat Units



Appendix B

Cost of Production Estimates

Imperial Units

Pumpkin

	1997	1998	1999	Average	Projected
Income ($/ac)					
Yield (lb/ac)	88,880	126,948	77,404	97744	90,000
Price ($/lb)	0.155	0.134	0.149	0.146	0.130
Gross Return	13,827	17,012	11,602	14,147	12,000
Expenses ($/ac)					
Variable Inputs					
Soil test	1	5	1	1	1
Seed	113	113	131	119	135
Fertilizer	80	82	47	70	85
Mulch	254	268	345	289	345
Row cover	1,075	1,437	0	837	0
Bees	85	85	230	133	230
Irrigation	242	242	242	242	245
Utilities	13	13	13	13	15
Fuel	30	30	30	30	30
Repair	10	10	17	10	10
Packaging	97		1,076	391	800
Marketing	1,383	1,701	1,160	1,415	600
Freight	1,307	1,500	1,161	1,323	200
Op. interest	68	68	86	74	90
Total	4,758	5,554	4,539	4,964	2,786
Labour Cost	1,615	2,257	3,711	2,527	2,050
Fixed Costs					
Land	21	21	30	21	75
Buildings	121	121	61	121	100
Equipment	205	205	217	209	225
Irrigation	40	40	58	45	60
Taxes	4	4	4	4	5
Return to Mgt	58	58	38	51	60
Total	449	449	408	451	525
Gross Return	13,827	17,012	11,602	14,147	12,000
Total Expense	6,822	8,260	8,658	7,942	5,361
Net Return	7,005	8,752	2,744	6,205	6,639

Detailed labour costs, ($/ac)			
	1997	1998	1999
Wage rate	6.50	7.00	7.50
Pre-Harvest			
hours/ac	92.5	161.0	67.8
Total cost	601	1127	509
Harvest			
hours/ac	93.5	138.5	166.8
Total cost	608	970	1251
Post-Harvest			
hours/ac	62.5	22.9	260.2
Total cost	406	160	1951
Grand total	1615	2257	3711
Labour as a % of total variable cost			
	25.3	28.9	45.0

Carrot

	1997	1998	1999	Average	Projected
Income ($/ac)					
Yield (lb/ac)	51,073	39,930	17,474	36,159	48,000
Price ($/lb)	0.218	0.210	0.238	0.211	0.210
Gross Return	9,888	8,833	4,162	7,628	10,000
Expenses ($/ac)					
Variable Inputs					
Soil test	1	5	1	1	1
Seed	314	314	333	320	350
Fertilizer	80	80	43	68	50
Herbicide	15		26	14	30
Irrigation	10	10	10	10	10
Utilities	353	353	353	353	353
Fuel	36	36	36	36	40
Repair	62	62	62	62	60
Packaging	2,382	1,264	1,097	1,581	1,100
Marketing	880	883	416	726	600
Freight	333	333	114	260	700
Op. interest	72	65	60	66	70
Total	4,538	3,407	2,551	3,497	3,364
Labour Cost	2,951	2,931	1,921	2,601	1,950
Fixed Costs					
Land	21	21	30	24	30
Buildings	690	690	531	637	600
Equipment	478	478	267	408	300
Irrigation	45	45	46	45	50
Taxes	4	4	4	4	5
Return to Mgt	58	58	38	51	50
Total	1,296	1,296	916	1,169	1,035
Returns ($/ac)					
Gross Return	9,888	8,833	4,162	7,628	10,000
Total Expense	8,785	7,634	5,388	7,267	6,349
Net Return	1,103	1,199	-1,226	361	3,651

Detailed labour costs, ($/ac)			
	1997	1998	1999
Wage rate	6.50	7.00	7.50
Pre-Harvest			
hours/ac	45.3	42.1	53.0
Total cost	295	295	398
Harvest			
hours/ac	43.8	40.7*	42.0*
Total cost	285	285	315
Post-Harvest			
hours/ac	364.8*	335.9*	161.1*
Total cost	2371	2351	1208
Grand total	2951	2931	1921
Labour as a % of total variable cost			
	39.4	46.2	43.0

*estimated

Cabbage

	1997	1998	1999	Average	Projected
Income ($/ac)					
Yield (lb/ac)	61,525	50,166	80,610	64,100	75,000
Price ($/lb)	0.130	0.107	0.100	0.112	0.120
Gross Return	7,998	5,374	8,086	7,153	9,000
Expenses ($/ac)					
Variable Inputs					
Soil test	1	5	1	1	1
Seed	200	107	168	158	175
Fertilizer	80	82	43	68	85
weed/insect	30	30	36	32	40
Irrigation	10	10	10	10	10
Utilities storage	183	183	183	183	183
Fuel	36	36	36	36	36
Repair	62	62	62	62	60
Packaging	788	153	1,008	650	1,000
Marketing	672	537	809	673	550
Freight	513	637	900	683	900
Op. interest	66	64	81	70	75
Total	2,641	1,906	3,337	2,626	3,119
Labour Cost	2,254	1,602	2,631	2,163	2,800
Fixed Costs					
Land	21	21	30	24	30
Buildings	811	811	680	767	750
Equipment	45	45	210	100	250
Irrigation	40	40	46	42	45
Taxes	4	4	4	4	5
Return to Mgt	58	58	38	51	50
Total	979	979	1,008	988	1,130
Returns ($/ac)					
Gross Return	7,998	5,374	8,086	7,153	9,000
Total Expense	5,874	4,487	6,976	5,772	7,049
Net Return	2,124	887	1,110	1,376	1,951

Detailed labour costs, ($/ac)			
	1997	1998	1999
Wage rate	6.50	7.50	7.50
Greenhouse			
Hours/ac	30.4	62.2	15.0
Total Cost	198	435	113
Pre-Harvest			
hours/ac	95.3	92.5	148.0
Total cost	619	647	1112
Harvest			
hours/ac	221	72.6	151.0
Total cost	1437	508	1134
Post-Harvest			
hours/ac	w/above	1.7	36.0
Total cost		12	272
Grand total	2254	1602	2631
Labour as a % of total variable cost			
	46.0	45.7	44.1

Pepper

	1997	1998	1999	Average	Projected
Income ($/ac)					
Yield (lb/ac)	23,664	43,667	302	22,544	24,000
Price ($/lb)	0.454	0.449	0.460	0.454	0.500
Gross Return	10,755	19,604	139	10,166	12,000
Expenses ($/ac)					
Variable Inputs					
Soil test	1	5	1	1	2
Seed	493	290	625	469	750
Fertilizer	80	82	43	68	85
Mulch	254	268	345	289	350
Row cover	708	726	1,147	860	1,200
Herbicide	9	9	9	9	10
Water / drip	473	473	242	393	250
Utilities	33	33	33	33	40
Fuel	30	30	30	30	30
Repair	10	10	17	12	20
Packaging	1,442	1,582	16	1,013	1,250
Marketing	1,075	1,960	14	1,016	507
Freight	534	654	15	401	500
Op. interest	137	143	148	143	175
Total	5,279	6,265	2,685	4,737	5,412
Labour Cost	2,414	3,589	2,440	2,814	3,550
Fixed Costs					
Land	21	21	30	24	30
Buildings	549	549	395	498	450
Equipment	185	185	221	197	250
Irrigation	40	40	58	46	60
Taxes	4	4	4	4	5
Return to Mgt	58	58	38	51	50
Total	857	857	746	820	845
Returns ($/ac)					
Gross Return	10,755	19,604	139	10,166	12,000
Total Expense	8,550	10,711	5,871	8,371	9,807
Net Return	2,205	8,993	-5,732	1,795	2,193

Detailed labour costs, ($/ac)			
	1997	1998	1999
Wage rate	6.50	7.50	7.50
Greenhouse			
Hours/ac	26.0	46.2	11.0
Total Cost	169	349	80
Pre-Harvest			
hours/ac	175.0	163.0	209.0
Total cost	1138	1143	1565
Harvest			
hours/ac	118.0	428.9	112.0
Total cost	769	1204	787
Post-Harvest			
hours/ac	52.0	127.1	1
Total cost	338	893	8
Grand total	2414	3589	2440
Labour as a % of total variable cost			
	31.3	36.4	47.6

Cucumber

	1997	1998	1999	Average	Projected
Income ($/ac) (approx. case weight = 13 lb)					
Yield (cs 24/ac)	2,277	2,347	968	1,864	1,900
Price ($/cs)	$5.58	$5.36	$5.20	$5.38	$5.25
Gross Return	12,705	12,571	5,041	10,105	10,000
Expenses ($/ac)					
Variable Inputs					
Soil test	1	5	1	1	1
Seed	462	211	462	378	475
Fertilizer	80	82	43	68	85
Mulch	254	268	345	289	350
Row cover					
Bees	85	85	230	133	230
Irrigation	10	10	242	87	250
Utilities	33	33	33	33	40
Fuel	30	30	30	30	30
Repair	10	10	10	10	10
Packaging	1,584	1,581	657	1,274	1,300
Marketing	1,271	1,257	504	1,011	600
Freight	284	293	121	233	500
Op. interest	93	93	100	95	100
Total	4,197	3,958	2,778	3,642	3,971
Labour Cost	5,039	5,509	3,403	4,650	4,000
Fixed Costs					
Land	21	21	30	24	30
Buildings	124	124	130	126	150
Equipment	205	205	211	207	225
Irrigation	40	40	58	46	60
Taxes	4	4	4	4	4
Return to Mgt	58	58	38	51	50
Total	452	452	471	458	519
Returns ($/ac)					
Gross Return	12,705	12,571	5,041	10,105	10,000
Total Expense	9,688	9,919	6,652	8,750	8,490
Net Return	3,017	2,652	-1,611	1,355	1,510

Detailed labour costs, ($/ac)			
	1997	1998	1999
Wage rate	6.50	7.00	7.50
Pre-Harvest			
hours/ac	117.9	109.4	128.0
Total cost	766	766	960
Harvest			
hours/ac	437.2	830.7	201.0
Total cost	2841	3154	1505
Post-Harvest			
hours/ac	220.3	332.7	125.0
Total cost	1432	1589	938
Grand total	5039	5509	3403
Labour as a % of total variable cost			
	54.6	58.2	55.1

Saskatchewan Vegetable Production – An Opportunity Awaits

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Abstract

At 7% "in-season" self sufficiency, Saskatchewan imports about $20,000,000 of fresh vegetables annually. To further exploit this apparent diversification opportunity a vegetable project was initiated in 1996 to demonstrate newer production technologies and to obtain data for Saskatchewan based costs of production. One half acre sized fields of pumpkin, carrots, cabbage, peppers, cucumber, broccoli, cauliflower, romaine lettuce, celery, Brussels sprouts and cantaloupe have been grown and marketed to simulate commercial production. The results have shown that acceptable yields of suitable quality produce can be grown and superior quality where proximity to market is a factor. Net returns have been positive for the most part but, since labour is such a significant component of variable costs, productivity and efficient use of labour can be critical. These initiatives have given the vegetable industry in Saskatchewan further impetus and direction. A number of new producers and a new generation cooperative, currently in the formative stages, appear poised to further diversify the agricultural landscape with **SASK GROWN** fresh vegetables.

Introduction

Based on unload data Saskatchewan is only 7% self sufficient in "in-season" fresh vegetables. That self-sufficiency compares to 33% in Alberta and 57% in Manitoba.

The 93 % of in-season fresh vegetables imported into this province represent a direct loss to Saskatchewan's economy of about $20,000,000 annually. About 40 to 50 % of that money goes to vegetable growers in other Canadian provinces primarily Manitoba while the remaining 50 to 60 % goes to support the economy of the United States.

In 1996 the Canada-Saskatchewan Irrigation Diversification Centre (CSIDC) initiated a vegetable project to demonstrate production and newer technologies such as drip irrigation, mulch, mini-tunnels, floating row covers and wind protection. In 1997 and 1998 the Agri-Food Innovation Fund (AFIF) provided funding to carry on the project with eleven vegetable crops.

Project Format / Procedures

The vegetable crops were grown on 0.2 ha (½ acre) sized blocks to simulate a commercial operation. The resulting crops were harvested, washed, graded, packaged as appropriate and marketed to wholesale buyers to simulate commercial production. Data obtained was used to calculate a Saskatchewan based cost of production for each crop.

IRT (infrared transmissible) mulch was used alone or in combination with mini-tunnels and/or row covering where applicable for the pumpkin, cucumber, pepper and cantaloupe. To make most efficient use of the mulch, crops were planted in a double row configuration along the outer edge with the drip tape running between the two rows.

Wind protection was provided for the pumpkin, cucumber, cantaloupe and pepper by means of rye solid seeded between the mulch rows either the fall prior or early in the spring.

A waterwheel planter was used to transplant cabbage, peppers, cantaloupe, broccoli, cauliflower, romaine lettuce, Brussels sprouts and celery transplants through the mulch. Pumpkin and cucumber were also seeded through the mulch with the waterwheel planter. A Stanhay precision seeder was used to direct seed pelleted carrot seed on raised beds.

Field days and tours were held to demonstrate production techniques to interested individuals Wholesale buyers were invited to similar events to view the quality of the resulting crops and begin the process of encouraging the use of more **SASK GROWN** produce.

The resulting produce was harvested, washed, graded and packed as appropriate and moved to wholesale and / or processing markets. Peppers remaining at season end were processed and marketed as a frozen diced product.

Results

During the first year of the project, cumulative corn heat units were near average at 2369. The second year saw much higher values at 2545 and the last year much lower at 2077. This is compared to the long term average of 2253 (1931-1998). The heat loving crops pumpkin, cucumber and pepper performed exceptionally well the second year while cabbage, being a cool season crop, performed much better the third year.

Pumpkin

Pumpkin has produced the most impressive results. Yields from 87 to 143 t/ha (38.7 to 63.5 tons/ac) were achieved with an average price of $0.319/kg ($0.145/lb) (Table 1).

The quality of the pumpkin grown was excellent and well received. Most were completely orange in the field. Some later pollinated pumpkin required further ripening but there was very little loss due to green colour.

The net returns were positive each year ranging from a low of $7324/ha ($2964/ac) in the last year of the project to a high of $21675/ha ($8772/ac) in the second year. These results have encouraged a number of private operations to grow pumpkin. Since there is a limited market for pumpkins and it is also very seasonal, persons interested in growing pumpkins should exercise extreme caution.

Carrots

In terms of ease of production, quality, yield and market demand, carrot production was the more attractive option for further development. They are one of the few vegetable crops that can be entirely mechanized similar to potato

Bunched carrots (6 to 8 per bunch X 24 / case) returned the equivalent of 1740 cases/ha (704 cases/ac) valued at $20613/ha ($8342 /ac). This is for one production year of data.

Topped carrot yields ranged from a low of 19.6 t/ha (8.7 tons/ac) in 1999 to a high of 57.5 t/ha (25.5 tons/ac) in the first year of the project (Table 1). The higher yield would be more indicative of carrot production potential.

Of the total marketable crop an average of 78.3% was sold as a Canada No.1 product either in a 0.9 or 2.3 kg (2 or 5 lb) poly consumer pack while the remaining 21.7% was moved into the processing market.

The scale of this project did not lend itself to efficiencies in harvest nor in the washing, grading and packaging operation. As a consequence the actual costs did not result in a positive net return. Assuming machine harvest and a washing, grading and packaging line along with good storage, it would appear that net returns in the range of $7412 /ha ($3000/ac) could be achievable.

Cabbage

Comparison of direct seeded cabbage to transplant production in the first two years indicated yields of 62.8 t/ha (27.9 tons/ac) for transplants and 18.3 t/ha (8.1 tons/ac) for direct seeding. Transplant production incurred extra costs of $2000/ha ($807/ac). At an average selling price of $0.246/kg ($0.112/lb) the net return for transplant production was $11000/ha ($4430/ac) which more than covered the additional expense. In addition transplanted cabbage was harvested about 10 days earlier than direct seeded cabbage. In spite of a reasonable spraying schedule for flea beetles, root maggots and imported cabbage worm the direct seeded cabbage appeared to suffer more than transplants further encouraging the use of transplants.

The average yield from transplants over the three years of the project was 72 t/ha (32.0 tons/ac). With an average price of $0.246/kg ($0.112/lb) the gross returns were $17732/ha ($7179/ac) (Table 1).

Peppers

Pepper production is very weather dependent and as such results have been more variable than those obtained for the other crops. Total heat units not only affected yield but quality in terms of sizing and the volume of red peppers produced. Overall marketed yields ranged from 340 kg/ha (300 lb/ac) in the last year of the project to a high of 49200 kg/ha (43667 lb/ac) in the second year (Table 1).

Peppers are sold on the basis of size and color. Those not sufficiently sized can be sold as chopper grade for restaurants and institutions while red peppers for retail command a premium price. The price ranged from a low of $0.72 ($0.327) for green chopper peppers to a high of $2.60/kg ($1.18/lb) for retail red peppers.

The option making diced frozen peppers from produce picked immediately prior to freeze up was explored in the latter two years of the project and indicated that an acceptable product could be achieved. Efficiencies of scale and some degree of mechanization particularly with respect to the initial cutting would be required in order to make it economically viable.

Cucumber (slicing)

Cucumber production is a labour intensive crop requiring careful harvest every two days during the peak picking period. Moving vines too aggressively during harvest resulted in abrasion damage to young undeveloped fruit. This later resulted in scarring. These fruit were subsequently not saleable. A solution involved leaving the vines relatively intact while searching for harvestable fruit and removing those cucumbers with the least amount of vine disturbance.

Accordingly high harvest costs resulted in this crop being the least attractive in the project on the basis of net returns. Losses from scarring and temporary surpluses on occasion resulted in losses ranging from 20 to 36% of marketed yields.

Marketed yield ranged from a low of 2400 cases/ha (968 cases/ac) (24 count/case) as a result of lower heat units in the last year of the project to a high of 5820 cases/ha (2347 cases/ac) with gross dollar return ranging from $12500 to 31500/ha ($5041 to $12705/ac) (table 1).

Further mechanization in terms of picking aids and improved packaging efficiencies would significantly improve the economics of cucumber production.

The following crop results are based on preliminary data (1 – 2 years) hence caution is advised:

Broccoli

Harvest commenced July 30 and concluded October 8 well after a number of frosts. Other than turning slightly purple the heads were excellent quality. Larger heads allowed the broccoli to be packed for the most part as single heads. Harvesting frequency was critical with earlier harvests but slower development later in the fall allowed more flexibility in harvest and marketing.

The heads were field trimmed, placed in pallet bins, stored in the filacel cooler and subsequently graded, packed 14 count per case, top iced and shipped.

In 1999 a yield equivalent of 3043 cases/ha (1232 cases/ac) were marketed at an average price of $10.39 / case for a gross return of $31616/ha ($12800/ac) (table 1).

Cauliflower

Cauliflower was harvested earlier as a 12 count size head rather than a 9 count. This allowed a better quality whiter head to be marketed. Harvest commenced July 30 and concluded October 12. While several frosts did not damage the cauliflower it was very slow to size during latter September and early October.

A total of 2383 cases/ha (965 cases equivalent /ac) were marketed at an average price of $9.80 / case for a total return of $23363/ha ($9459/ac) (Table1)

Brussels Sprouts

This is a labour intensive crop when harvested by hand. In addition the sprouts are difficult to remove and would create some distress to workers with a larger area to harvest. The average quantity harvested was 20.1 kg (44.4 lb) per person per hour but ranged from 13.7 to 28.3 kg (30.3 to 62.3 lb) per person per hour.

A total of 16262 kg/ha (14520 lb/ac) equivalent was marketed at an average return of $1.25/kg ($0.557/lb) for a gross return of $19962/ha ($8082/ac) (Table1). The quality of the sprouts seemed acceptable but variability in size may require some mechanical means of sizing.

The success of this crop will depend on the introduction of some means of mechanical harvest.

Celery

This is a long season crop requiring transplants started in March and field planted in early June after the temperature remains above 10C (50 F). In addition it is a crop that needs and responds well to good moisture levels throughout the growing period.

The celery was harvested commencing September 8 and concluded October 12 at which time it had been exposed to several frosts. The celery marketed was very good quality with good-sized hearts both in length and diameter. There was very little stringiness.

A total of 1280 (24 count) cases/ha (518 cases/ac) equivalent was marketed at an average price of $12.72 per case for a gross of $16270/ha ($6587/ac) (Table 1). Some difficulty with head formation was experienced resulting in this lower than expected yield.

Romaine Lettuce

The Romaine lettuce was sequentially planted. The bulk of the harvest originated from the first two plantings. The quality of this production was excellent with good-sized heads and no tip burn. Lettuce maturing later in the mid-summer heat did not form adequate heads for harvest.

The equivalent of 1764 cases (24 count) /ha (714 cases/ac) was marketed at an average price of $8.48 per case giving a gross return of $14958/ha ($6056/ac) (table 1). This compared to $11.99 / case received in 1998. The depressed price was the obvious reason for this lower return.

Cantaloupe

Consumers continue to be impressed with the quality of **Sask Grown** cantaloupe picked at or close to full slip. Sugar content of this cantaloupe was as high as 13% but more normally in the 9 to 12 % range. Imported cantaloupe harvested several days prior to full slip to accommodate shipping requirements was about half that percentage. Identifying locally grown cantaloupe, which is essentially identical to imported produce in appearance, and subsequently promotion will be essential to command a premium for this superior quality.

A yield of 1704 cases/ha (690 cases/ac) was marketed at an average price of $12.47 per case for a gross return of $21252/ha ($8604/ac) (Table 1). Cantaloupe is sold by count (9, 12, 15, 18 or 23 / case).

Table 1. Yields, Prices, Gross and Projected Net Returns of Eleven **Sask Grown** Vegetable Crops

CROP	YIELDS (/ac) (range)	PRICE (range)	GROSS RETURNS/ac	PROJECTED NET RETURNS /ac
Pumpkin	*97744 lbs (77404-126948)*	*$0.146 /lb (0.134-0.155)*	*$14147 (11602-17012)*	*$7925 (2964-8772)*
Carrot	*36159 lbs (17474-51073)*	*$0.222 /lb (0.210-0.238)*	*$7628 (4162-9888)*	*$721 (-801-1548)*
Cabbage	*64100 lbs (50166-80610)*	*$0.112 /lb (0.10-0.13)*	*$7153 (4309-6726)*	*$1562 (1065-2268)*
Pepper	*22544 lbs (302-43667)*	*$0.495 /lb (0.454-0.570)*	*$10166 (139-19604)*	*$1818 (-5692-8933)*
Cucumber	*1864 cs 24ct (968-2347)*	*$5.38/cs (5.20-5.58)*	*$10105 (5041-12705)*	*$1377 (-1578-3011)*
Broccoli	*1232 cs 14ct*	*$10.39 /cs*	*$12800*	*$4250*
Cauliflower	*965 cs 12 ct*	*$9.80 /cs*	*$9459*	*$605*
Romaine Lettuce	*714 cs 24 ct*	*$8.49 /cs* ($11.99- 1998)	*$6056*	*-$871 ($1633)*
Brussels Sprouts	*14520 lbs*	*$0.56 /lb*	*$8082*	*$645*
Celery	*518 cs 24 ct*	*$12.72 /cs*	*$6587*	*-$1451*
Cantaloupe	*690 cs 9 to23 ct*	*$12.47 /cs*	*$8604*	*$370*

Labour

The most significant cost associated with vegetable production in this project was labour. As a percentage of variable costs, labour ranged from a low of 33.2% for pumpkin to a high of 63.4% for romaine lettuce. The average was 48.6%.

The development of mechanization and efficient operating systems is an essential requirement to improve the profitability for commercial operations. Secondly managing the human resource by selecting suitable employees, motivating employees and rewarding productivity to is equally important to ensure efficiencies.

Cost of Production

A detailed cost of production analysis based on actual experience for each of the three years along with an average and a projection for each crop is provided. The projected cost of production for each crop reflects an estimation of what a commercial operation should reasonably expect in terms of yields, returns and costs. More years of data are required to provide more accurate estimations.

This data indicates that pumpkin production provides the best net return of the crops grown in this project. Caution is advised since the market is limited and very seasonal. Carrots followed closely by cabbage would present the next best alternative on the basis of these results. Mechanization would, however, be essential.

Pepper production is more dependent on warmer weather than any other of the crops grown in this project. Accordingly, caution is advised until longer-term experience can be gained particularly on newer technologies such as the high tunnel option. The option to profitably process peppers into a diced frozen product during or at the end of the season would ameliorate this conclusion significantly.

Labour cost associated with cucumber harvesting made this crop the least attractive in the project. The challenge to grow slicing cucumbers commercially would be to devise a harvesting procedure or system that would reduce harvest costs or accept those costs more as a return to labour as opposed to management.

Conclusion

The results from this project have shown that acceptable yields of suitable quality produce can be grown in Saskatchewan. Where proximity to market is a factor allowing more timely harvest and delivery then superior quality produce can be offered to the trade. Net returns have been positive for the most part. Since labour is such a significant component of variable costs, productivity and efficient use of labour can be critical.

This project has already resulted in additional private production, particularly with pumpkin, and much interest in other vegetable crops. A new generation cooperative, in the formative stages, is an attempt to further develop the vegetable industry by coordinating marketing to the wholesale / retail and processing market.

The Canada food guide recommends the consumption of five to ten servings of fruits and vegetables per day for a healthy diet. Why not make it **SASK GROWN?**

AGRI-FOOD INNOVATION FUND
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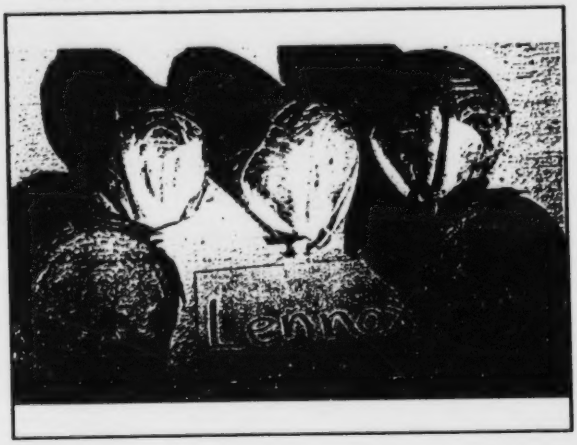

Final Report for:

Cool Season Vegetable Demonstration Project in North-East Saskatchewan

Conducted by

Department of Plant Sciences
University of Saskatchewan
2000

AGRI-FOOD INNOVATION FUND

JUL 11 2000
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Final Report for : AFIF Horticulture Sector
Demonstration of Cool Season Vegetable Crops in the North-East of Saskatchewan

Prepared by : **Doug Waterer, Vegetable Crops Specialist, Department of Plant Sciences, University of Saskatchewan**

Executive Summary : During the 1997, 1998 and 1999 cropping seasons, this project evaluated the relative earliness, yields and quality of several cool season vegetable crops produced at differing locations across central Saskatchewan. The project objective was to determine the relative suitability of differing production areas for anticipated expansion of the vegetable industry in Saskatchewan. A second objective was to identify varieties that performed well under Saskatchewan growing conditions and met local market requirements for quality. Crops evaluated included cabbage, carrots, broccoli and cauliflower. These crops are adapted to Saskatchewan growing conditions, and markets for these commodities have been identified. The production sites (Nipawin, Outlook and Saskatoon) sites represent potential areas for expansion of vegetable production.

Based on yields and crop quality observation over the three test seasons (1997-1999), each site had strengths and limitations. Yields and quality in three test seasons were exceptionally high for almost all crop/site combinations, which supports the perception that there are significant opportunities to increase production of these adapted vegetable crops in Saskatchewan.

1997 - Yields and crop quality were quite similar at the various test sites for cabbage. For carrots, broccoli and cauliflower, the Outlook and Saskatoon sites were substantially superior to the Nipawin site. Irrigation enhanced yields of all crops except the cabbage. Irrigation had little impact on crop quality.

1998 - limited rainfall coupled with warm growing conditions resulted in significant drought stress at the dryland site. Yields and quality of all the crops were reduced by this stress. When irrigation was available, yields of all test crops were comparable for the three test sites.

1999 - despite the relatively abundant rainfall in 1999, the dryland site again was slower to develop, lower yielding with a higher incidence of gradeout to malformation than when the crops were irrigated. When irrigation was available, the Nipawin site produced yields comparable to the other test sites.

This project identified high yielding cultivars which also met market standards for quality. Some of the cultivars were better suited to one site than another.

Project Background

Saskatchewan presently imports about $ 20 million of vegetables annually. Only 7% of the provinces "in-season" vegetable crop needs are produced within the province. The adjacent provinces of Manitoba and Alberta presently supply more of Saskatchewan's annual vegetable crops needs than do growers within the provinces borders.

A number of underlying factors can be identified for the small size of the vegetable industry in Saskatchewan relative to the potential demonstrated by the value of imported commodity and the relatively robust nature of the vegetable sectors in the adjacent provinces. One of the most commonly mentioned contributors is the perception that the climatic conditions in Saskatchewan are not favorable to vegetable crop production. The fact that climatic conditions in Saskatchewan are roughly comparable to the adjacent provinces would suggest that this is not a valid concern. The fact that there are growers successfully producing a range of vegetable crops in diverse locations in Saskatchewan would also suggest a wider potential. Crops such as carrots, cabbage and lettuce thrive under the relatively cool conditions characteristic of Canadian Prairies providing the crops' moisture needs can be met. Typical precipitation levels on the Prairies are well below the optimum requirements of most vegetable crops. Sensitivity to moisture stress varies across vegetable types. For example carrots are very sensitive to stress, particularly as the roots are beginning to develop. By contrast, potatoes and cabbage are relatively drought tolerant - although their yields may suffer as a consequence of extended periods of moisture deficit. Rainfall in Saskatchewan increases as you move northeast across the province. Dependance on irrigation would be expected to follow a corresponding pattern.

The primary objective of this project was to determine the relative suitability of differing production areas for anticipated expansion of the vegetable industry in Saskatchewan. The project focussed on cool season vegetable crops as there is a demonstrated potential for production of these crops in Saskatchewan and demand for these crops is expanding.

Crops evaluated included cabbage, carrots, broccoli and cauliflower. These crops are adapted to Saskatchewan growing conditions, and markets for these commodities have been identified. The production sites (Nipawin, Outlook and Saskatoon) sites represent potential areas for expansion of vegetable production. The Outlook area is in the heartland of the Lake Diefenbaker irrigation district. The Lake Diefenbaker also typically receives more heat units during the growing season than any other area in the province. Warmer conditions may allow for early planting and extended harvest period - thereby enhancing yields. The Saskatoon site is cooler than Outlook and features a heavy clay soil not well suited to vegetable crop production. To its advantage, this is a very highly managed site, ideally situated in a sheltered location and equipped with the very best of crop management equipment and expertise. This site effectively indicates what can be done for the crop through management. The Nipawin area is renowned for production of excellent yields of crops such as canola which are adapted to cool steady weather. This suggests that this region may also have potential for the production of cool season vegetable crops.

A second objective of the project was to identify varieties of each test crop that performed well under Saskatchewan growing conditions while also meeting local market requirements for quality.

The crops selected for testing were;

Carrots - Saskatchewan presently imports over 90% of its in-season carrot requirements. Grower experience indicates a potential for successful carrot production in Saskatchewan. However, effective storage and marketing of the crop have been problematic in the past. Identification of a market for the culls would further enhance the viability of carrot production in Saskatchewan.

Cabbage - the province presently supplies about 40% of its in-season requirements for cabbage. Acreage devoted to fresh market cabbage and particularly cabbage for storage has declined over the last several years as growers opt for less labor intensive and more profitable crops. This decline comes at a time when demand for fresh cabbage is stable and opportunities exist for processing the crop. Processors in Saskatoon and Delisle are relying on imports for the vast majority of their cabbage needs. This indicates a significant market potential for storage type cabbage production.

Broccoli and Cauliflower - Manitoba and Alberta produce significant acreages of these high-value crops. The success in adjacent provinces, coupled with the results from University of Saskatchewan trials suggests that growing conditions in Saskatchewan would also be suited to these crops. These crops are labor intensive to harvest and the labor issue will represent a challenge to growers considering these crops.

The test sites were;

Outlook SIDC Field Research Station
The site featured a sandy loam soil, pH 8.0. E.C. 1.5 dS/m2. The site has limited shelter and has been cropped to vegetables since 1993. The sandy soil at this site holds little N but is fairly abundant in $P_2 0_5$ and $K_2 0$. The site is overhead irrigated.

Saskatoon Horticulture Science Field Research Station
This site features a clay soil, pH 6.9, E.C. <1.0 dS/m^2. The site has an extensive shelter belt system and has been consecutively cropped to vegetables for 20 years. The site has been heavily fertilized for over a decade and features high residual levels of N, P and K. The site is overhead and drip irrigated

Nipawin Grindstone Market Gardens (Rod Peterson)
The site features a sandy loam soil, pH 7.4, E.C. <1.0 dS/m^2. The site has extensive shelter, with some slope. The farm has been in vegetables for 10 years. The test site was green manured in 1996 and was in vegetables in 1997. The initial fertility (0-12") was 42#/a N, 48#/a $P_2 0_5$, 500#/a $K_2 0$

These sites were selected as representatives of the potential range of growing environments available in Central Saskatchewan.

esults

eather data

1997 Growing Season

WEATHER DATA						
	May	June	July	Aug.	Sept.	Season Ave.
	Mean Temperature (°C)					
Nipawin	8.8	16.6	18.4	17.5	13.0	14.9
Outlook	11.1	17.5	19.0	18.7	15.0	16.2
Saskatoon	10.7	17.4	19.2	19.0	14.6	16.2
Long-Term Average	11.2	15.6	18.4	17.2	11.5	13.1
	Sunshine Hours					
Nipawin	229	235	361	278	203	261
Outlook	190	240	408	255	180	255
Saskatoon	219	245	307	287	220	256
Long-Term Average	285	299	333	295	188	261
	Frost Free Season					
Nipawin	May 20 to September 20 = 123 days					
Outlook	May 8 to October 5 = 144 days					
Saskatoon	May 15 to October 5 = 143 days					
Long-Term Average	Saskatoon 118, Outlook 123, Nipawin 110 days					

The 1997 growing season was excellent for irrigated vegetable production. After a cool period in mid-May with the final spring snowfall on May 17, temperatures increased and a typical hot dry prairie summer ensued. Rainfall in the Saskatoon and Outlook regions was limited throughout the summer. In Nipawin, total rainfall received during the season was 26 cm which is slightly below the 30 year average for the site (30 cm). A relatively dry late May and June limited or delayed germination on the dryland plots in Nipawin. Rainfall in Nipawin in July, August and September was ample. A hailstorm in Nipawin in mid-June damaged the cabbage plants however, growing points were not destroyed and most crops completely recovered. A long, dry fall ensured that all crops were completely harvested prior to a killing frost.

1998 Growing Season

WEATHER DATA						
	May	June	July	Aug.	Sept.	Season Ave.
	Mean Temperature (°C)					
Nipawin	11.5	14.2	18.3	19.0	12.4	15.1
Outlook	13.3	15.2	20.2	20.6	14.5	16.8
Saskatoon	13.0	14.5	18.7	20.0	13.3	15.9
Long-Term Average	11.2	15.6	18.4	17.2	11.5	13.1
	Sunshine Hours					
Nipawin	302	221	312	329	n/a	291
Outlook	n/a	n/a	n/a	n/a	n/a	n/a
Saskatoon	349	233	306	330	198	283
Long-Term Average	285	299	333	295	188	261
	Frost Free Season					
Nipawin	May 20 to September 30 = 134 days					
Outlook	May 13 to October 11 = 152 days					
Saskatoon	May 31 to September 30 = 123 days					
Long-Term Average	Saskatoon 118, Outlook 123, Nipawin 110 days					

The 1998 growing season was excellent for irrigated vegetable production. Average temperatures exceeded the 50 year record. Rainfall was limited from July through early September, but was abundant through the fall. Early season drough caused problems with stand establishment and early growth in the rainfed trials in Nipawin. A long, fall helped maturity but many cultivars of cabbage and some direct seeded cauliflower did not mature prior to termination of the trial in late October. A heavy snow fall in early October delayed harvesting but had little negative impact on yields or quality.

WEATHER DATA						
	May	June	July	Aug.	Sept.	Season Ave.
	Mean Temperature (°C)					
Nipawin	11.5	14.2	18.3	19.0	12.4	15.1
Outlook	13.3	15.2	20.2	20.6	14.5	16.8
Saskatoon	13.0	14.5	18.7	20.0	13.3	15.9
Long-Term Average	11.2	15.6	18.4	17.2	11.5	13.1
	Sunshine Hours					
Nipawin	302	221	312	329	n/a	291
Outlook	n/a	n/a	n/a	n/a	n/a	n/a
Saskatoon	349	233	306	330	198	283
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1999 Growing Season

WEATHER DATA						
	May	June	July	Aug.	Sept.	Season Ave.
	Mean Temperature (°C)					
Outlook	10.8	15.2	17.0	18.3	11.2	14.5
Saskatoon	10.7	14.6	16.4	17.8	10.3	14
Long-Term Average	11.2	15.6	18.4	17.2	11.5	14.8
	Sunshine Hours					
Outlook	n/a	n/a	n/a	n/a	n/a	n/a
Saskatoon	185	264	3.8	267	231	250
Long-Term Average	285	299	333	295	188	280
	Frost Free Season					
Outlook	May 7 to September 13 = 129 days					
Saskatoon	May 7 to September 13 = 129 days					
Long-Term Average	121 days					

The 1999 growing season was excellent for cool season vegetable production. Average temperatures were slightly below normal while rainfall was well above normal. These conditions were particularly beneficial at the dryland site in Nipawin. A long, relatively frost free fall helped maturity but some of the late cultivars of cauliflower and cabbage failed to mature prior to the termination of the trials in late October.

arrot Trial

This trial evaluated the yields and quality of Danvers, Nantes and Imperator type carrots. Nantes are regarded as a remium fresh market type of carrot. They are generally small and early and have an exceptionally high sugar content which makes them popular for fresh consumption. Their main limitation is their sensitivity to damage during harvest and subsequent handling. Nantes carrots also have a limited storage lifespan. Danvers carrots are early, moderately long and high yielding with a moderate sugar content. Danvers type carrots are highly tolerant of mechanical handling and have a long storage lifespan. Imperator carrots are long and thin with a moderate sugar content and acceptable storage lifespan. Yields of Imperator carrots can be very high if the growing season is long nough. The length of the Imperator carrots can cause problems in shallow soils and during mechanical harvest.

Cultivars of each type of carrot were selected for their superior performance in trials previously conducted by the Horticulture Science Department at the University of Saskatchewan. Replicated versions of this trial were conducted at the Outlook and Nipawin sites, while a non-replicated version was conducted on the heavy clay soil at the Saskatoon site.

Site Preparation

All sites were initially disced to 8" to incorporate crop residues and the fertilizer. In Nipawin, in 1997, no further soil preparation was used although clods and crop residue were raked aside. In 1998 and 1999, the carrot plots in Nipawin were rototilled prior to seeding to improve the seedbed. The Outlook site was rototilled in all three years to produce uniform, smooth conditions. At the Saskatoon site, the heavy clay soil was lightly rotovated and then a bed shaped was used to gather the lighter top soil into a raised bed. Each bed was approximately 20 cm high, 40 cm wide at the base and 20 cm wide at the top. The top of the bed was smoothed and the two rows of carrots were seeded approximately 10 cm apart in each bed.

Fertility

Fertilizers were applied at each site to raise N and P levels to provincial recommendations for carrots (100 #/a N and 60#/a P2O5). All three sites tested higher than the provincial recommendation for K. The crop was seeded in early May at all three sites using a push-type Precision Planter, equipped with a standard carrot seeding disk. The crop was seeded ½" deep at the Saskatoon and Outlook sites where irrigation was available. At the Nipawin site, irrigation was not available at planting, so the seed was planted to moisture (1.5" deep). Twin rows of each cultivar were seeded 15 cm apart in 8 m long rows replicated three times at each site (randomized complete block design).

Pest Control

Treflan (trifluralin) was applied pre plant and Lorox (Linuron) was applied when the crop reached the two true leaf stage. Weed control for the duration of the season was excellent at all sites. No significant pest or disease problems were observed, except some Aster Yellows. Aster Yellows is a common viral disease of carrots which is spread by leaf hoppers. No attempt was made to control leaf hoppers at any site.

Moisture Management

At the Saskatton and Outlook sites, overhead irrigation was used to maintain soil water potential above -40 kPa through the growing season. Irrigation usually occurred weekly, with an average of 1.5 cm applied/irrigation. The grower co-operator handled the Irrigation at the Nipawin site. Irrigation scheduling at this site was determined by

availability of irrigation equipment.

1997 - a total of 15 cm was applied at the Saskatoon and Outlook sites and 10 cm at Nipawin. Half of the Nipawin site was left non-irrigated. Rainfall was spotty from late June through early August.

1998 - a total of 18 cm was applied at the Saskatoon and Outlook sites and 10 cm in Nipawin. Rainfall was limited from July through early September. There was abundant rain in September and October.

1999 - rainfall was abundant from seeding through until mid-July. A total of 10 cm of irrigation was applied at the Saskatoon and Outlook sites with only 6 cm in Nipawin. There was limited rain in September and October.

Harvest and Data Collection

Plots were hand dug and sampled for yield and root quality in the third week of August (early harvest) and again in late September (final harvest). Yields were determined both before and after the roots were graded according to industry standards for size, uniformity and freedom from defect. Representative samples of carrots from each site and harvest combination were frozen immediately after harvest and held at -40°C until analysed for sugar content. The soluble solids content in the cell sap was measured using a hand-held refractometer. In carrots, the soluble solids are largely sugars such as sucrose and fructose.

Data Analysis

To allow for general comparisons of the sites and the overall performance of the cultivars, the sites were considered as fixed variables in a preliminary data analysis. Data for individual sites were then analysed separately.

Carrot Results - 1997

Yields and quality characteristics for the two harvests at the three test sites are presented in Table CAR-1997-1. These data represent the averages for the cultivars tested. Yields and quality characteristics of the 10 cultivars tested are presented in Table CAR-1997-2. These data represent the averages over the three test sites. Cultivar performance at the individual test sites is presented in Appendices CAR-1997 A, B and C. Marketable yields at both the early and late harvests at all sites are in line with provincial averages (20 t/ha).

Table CAR-1997-1. Yield and Quality Characteristics for Carrots at Three Sites in Saskatchewan in 1997.

	Harvest 1		Harvest 2		Flavor			Harvest 1			Harvest 2		
	Total t/ha	Mkt. t/ha	Total t/ha	Mkt. t/ha	Harv. 1	Harv. 2	Sweet	Core (cm)	Leng. (cm)	Width (cm)	Core (cm)	Leng. (cm)	Width (cm)
Outlook													
	53.9a	29.3a	87.6a	37.6a	3.2a	2.6a	2.7a	1.1b	14.1b	2.4a	1.2b	14.6b	2.9ab
Nipawin													
Dryland	14.2c	7.4c	29.8c	10.5c	2.75	2.5a	1.6a	1.3a	17.3a	2.4a	1.3a	17.8a	3.1a
Irrigated	20.6b	12.5b	46.1b	17.2b	-	1.8a	1.9a	1.1b	17.6a	2.3a	1.2b	16.8a	2.8b
Average	**29.6**	**16.5**	**54.2**	**21.8**		**2.3**	**2.1**	**1.2**	**16.4**	**2.4**	**1.2**	**16.5**	**2.9**

Values within each column followed by the same letter are not significantly different
Flavor and sweetness 0 = poor and 5 = excellent

At the early harvest, total and marketable yields at the irrigated Outlook site were double the irrigated site in Nipawin and four times as high as dryland site in Nipawin (Table CAR-1997-1). The proportion of the crop meeting market standards was similar at the three trial sites (average of 55%). This level of grade out is higher than desirable, but is not uncommon in carrot production. On average, the carrots were longer at both Nipawin sites than in Outlook (Table CAR-1997-1). The Nipawin site features a uniform deep soil favorable to root growth of carrots, while in Outlook there is a plough pan at 25 cm. There were no consistent differences in the taste or sweetness of the carrots between the three sites at the early harvest. Presto produced outstanding total yields at the early harvest, but grade out was such that its marketable yields were no better than the other test lines (Table CAR-1997-2).

Table CAR-1997-2. Yield and quality characteristics for carrots cultivars averaged over three sites in Saskatchewan in 1997.

					Taste		Length (cm)		Width (cm)	
	Total t/ha	Market t/ha	Total t/ha	Market t/ha	Harv.1	Harv.2	Harv.1	Harv.2	Harv.1	Harv. 2
Presto	45.3_{a}	24.5_{a}	69.3_{a}	26.4_{a}	3.5_{a}	2.2_{abc}	14.1_{d}	14.1c	2.4_{a}	2.7_{c}
Karamana	35.8_{ab}	20.8_{a}	64.4_{a}	26.7_{a}	3.6_{a}	1.5_{bc}	15.1_{cd}	15.2_{bc}	2.5_{a}	3.1_{ab}
Healthmaster	28.4_{ab}	17.3_{a}	55.1_{a}	23.2_{a}	2.8_{a}	1.2_{c}	15.0_{cd}	15.0_{bc}	2.5_{a}	3.2_{a}
Earlibird Nantes	22.2_{b}	12.3_{a}	49.3_{a}	18.5_{a}	3.5_{a}	3.0_{ab}	14.2_{d}	14.7_{c}	2.4_{a}	3.0_{abc}
Choctaw	30.4_{ab}	16.0_{a}	47.8_{a}	16.4_{a}	2.0_{a}	2.2_{abc}	18.0_{ab}	17.8_{a}	2.3_{ab}	2.8_{bc}
Carobest	25.9_{ab}	14.2_{a}	52.5_{a}	20.9_{a}	2.0_{a}	2.3_{abc}	18.4_{ab}	18.3_{a}	2.1_{b}	2.7_{c}
Cheyenne	26.5_{ab}	15.4_{a}	48.6_{a}	19.8_{a}	3.5_{a}	2.2_{abc}	19.9_{a}	18.3_{a}	2.4_{ab}	3.0_{abc}
Caropak	21.7_{b}	12.2_{a}	43.9_{a}	17.6_{a}	2.8_{a}	1.8_{bc}	17.0_{bc}	18.2_{a}	2.2_{ab}	2.9_{abc}
Eagle	27.5_{ab}	13.8_{a}	51.3_{a}	21.9_{a}	3.0_{a}	2.0_{bc}	17.9_{ab}	16.9_{ab}	2.4_{a}	3.0_{abc}

Values within each column followed by the same letter are not significantly different
Flavor and sweetness 0 = poor and 5 = excellent

Total yields at the final harvest were substantially higher than at the early harvest (Table CAR-1997-1). However, grade out to abnormalities increased between the two harvests (45% for harvest 1 versus 60% for harvest 2) and consequently marketable yields were only marginally higher than for the early harvest. Relative yields for the differing sites at final harvest followed the same pattern established at the early harvest (Outlook > Nipawin Irrigated > Nipawin Dryland). Marketable yields in Outlook were above industry averages, while the Nipawin dryland site was low by comparison with the average established for irrigated production. At the final harvest differences in total and marketable yield of the various cultivars were minor by comparison with the first harvest (Table CAR-1997-2).

At the final harvest, there were substantial differences between the cultivars for taste and sweetness, however, variability between sites and reps made these differences statistically non-significant (Table CAR-1997-2). Contrary to expectation, overall sweetness did not increase between the early and final harvests (Table CAR-1997-2) Some lines (Bolero, Earlibird Nantes) showed superior sweetness and taste at the final harvest, while others (Karaman, Healthmaster, Eagle and Caropak had lost a substantial degree of sweetness or developed a poor flavor by late fall.

Length/Width

The varieties showed the length/width characteristics expected for the various type categories (Nantes <Danvers < Imperator)(Table CAR-1997-2). The site of production had little impact on these characteristics (Table CAR-1997-1).

Sugar Analysis

Samples taken at each site and harvest were frozen for analysis of sugar content. A 2 cm section from the mid-section of four carrots was ground using a food processor. The pulp was filtered from the juice prior to determination of the sugar content (% BRIX) using a refractometer. The harvests and sites were considered as fixed variables in the analysis of the sugar content data (Table CAR-1997-3).

Table CAR-1997-3 Analysis of variance for sugar content (% BRIX) of several cultivars of carrots grown at three sites in Saskatchewan and harvested at two times.

	F-Test Probability
Harvest (H)	0.39
Site (S)	**
Cultivar (C)	***
H * S	0.43
H * C	0.45
S * C	0.67
S * C * H	0.16

Mean values for treatment main effects

	% BRIX
Harvest 1	8.82
Harvest 2	8.74
Outlook	9.02 a
Nipawin - Irrigated	8.73 b
- Dryland	8.60 b
Bolero	9.38 a
Caropak	9.33 a
Carobest	9.22 a
Cheyenne	8.97 ab
Chocktaw	8.96 ab
Kamaran	8.95 ab
Healthmaster	8.60 b
Earlibird Nantes	8.58 b
Eagle	8.48 b
Presto	7.37 c

(For each variable, values followed by the same letter are not significantly different).

The refractometer confirmed the results from the taste trials indicating no change in sugar content from the early to the final harvest. The taste trials had indicated no consistent difference in taste or sugar content over the three trial sites. However, the BRIX values from Outlook were significantly higher than from Nipawin. This difference may be of questionable practical significance as it was not noted in any of the taste comparisons. It is interesting that some lines (ie. Bolero) rated as sweet in the taste trials also had a high BRIX and some low sugar lines (Eagle) were also rated poor for sweetness in taste panels. There were some cases however where the sweetness rating from the taste

panel did not correspond with the BRIX data. For example, Earlibird Nantes rated highly in the taste panels, but had a very low sugar content according to the BRIX test. This suggests that factors other than sugar content were influencing the perception of "sweetness" in the taste trials. Earlibird Nantes is renowned for its juiciness and mild flavor.

Correlation between cell K content and BRIX sugar content.

The samples tested for sugar content (% BRIX) using the refractometer were also examined for tissue K content using an ion-specific electrode (Cardy Meter). A total of 298 samples were evaluated. The correlation between sugar content and tissue K levels was then examined.

K+	mean	2045 ppm± 488	range 915-3700
BRIX	mean	8.80%± 0.93	range 6.25-11.65

Spearman's product moment test indicated a significant (p=0.0001) correlation between the K+ content and % BRIX of the samples. Similarly, regression analysis indicated a significant linear relationship between K+ levels and the BRIX content which could be expressed by the following equation

BRIX % = K+ content (ppm) * 7.4 * 10^{-4} + 7.27 R^2 = 0.15***

Although this relationship was statistically highly significant, variability in cell K content only explained 38% of the variation observed in the BRIX data. Other factors, genetics and environment, likely represent more consistent determinants of sugar levels in carrots. It is nonetheless noteworthy that the accumulation of sugars in carrots is not strictly linked to availability of K in the environment or within the cell.

arrots - 1998

able CAR-1998-1. Yields and quality characteristics for carrots at two harvest dates and three production sites in Saskatchewan in 1998.

	Total (t/ha)		Marketable (t/ha)		Marketable (%)		Length (cm)		Taste (0-5)		Brix (%)	
	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d
Bolero	16.1	61.3	8.4	13.4	50.0	28.0	16.0	18.0	2.1	2.6	9.0	10.2
Carobest	19.9	56.6	11.1	22.6	55.0	38.0	20.0	20.0	1.8	1.8	9.0	9.4
Cheyenne	16.4	57.4	11.5	17.9	64.0	34.0	23.0	22.0	2.5	2.1	8.4	9.3
Choctaw	23.6	61.2	14.5	10.8	58.0	18.0	21.0	20.0	1.4	1.6	8.6	9.9
Eagle	25.9	67.6	18.6	15.9	68.0	23.0	20.0	23.0	2.2	1.6	8.7	9.4
Earlibird Nantes	25.7	53.0	19.2	19.3	71.0	37.0	15.0	16.0	2.5	3.0	8.3	9.2
Healthmaster	28.7	76.1	16.5	24.7	53.0	30.0	15.0	16.0	2.6	1.8	8.4	9.4
Kamaran	32.4	88.8	17.0	24.3	49.0	28.0	16.0	16.0	3.8	3.2	8.5	9.6
Nandrin	25.7	71.2	17.1	23.9	65.0	34.0	16.0	18.0	2.9	3.2	7.9	9.2
Presto	35.9	72.7	21.9	22.9	59.0	30.0	15.0	15.0	2.8	3.2	7.6	8.5
LSD	*11.9*	*26.6*	*9.1*	*13.5*	*15.0*	*17.0*	*1.0*	*3.0*	*1.3*	*1.1*	*0.7*	*1.1*
Nipawin Dryland	13.4c	37c	6.3c	7.2c	46b	20b	17b	16.0	2.3ab	2.3	8.8	10.3
Nipawin Irrigated	24.9b	95.7a	16.5b	15.7b	67a	17b	17b	18.0	3a	2.4	8.1	8.7
Outlook	30.6b	67.4b	20.3b	32.5a	66a	47a	18ab	20.0	2.2ab	2.2	8.7	9.6
Saskatoon	43.6a	64.6b	26.2a	29.1a	56b	44a	19a	21.0	2.1b	2.8	8.3	9.1
Mean	28.1	66.2	17.3	21.1	59.0	32.0	18.0	18.0	2.4	2.4	8.5	9.4
LSD	*6.9*	*12.8*	*5.2*	*7.0*	*9.0*	*8.0*	*1.0*	*2.0*	*0.8*	*0.8*	*0.5*	*0.5*

Yields and quality characteristics of the various cultivars tested for the two harvests are presented in Table CAR-1998-1, along with data for the three test sites (averaged over cultivars). Cultivar performance at the individual test sites is presented in Appendices CAR-1998 A, B and C.

At the early harvest, total and marketable yields at the irrigated Saskatoon site were higher than the other irrigated sites. Grade out was moderate at the early harvest. At the final harvest, the irrigated plots in Nipawin produced the highest total yields, however, grade outs were high at this site. It appears that downward growth of the carrots was

restricted at this site due to moisture stress or the presence of a plough pan. Final marketable yields for the Saskatoon and Outlook sites were comparable and were well above the provincial average of 20 t/ha. Final yields under dryland conditions in Nipawin were exceptionally poor with low yields combining with high levels of gradeout to abnormal shape. Problems with gradeout can be expected in situations where moisture supply is erratic. On average, the carrots were slightly longer in Outlook and Saskatoon than at both Nipawin sites. This likely reflects differences in the depth of tillage prior to planting. Both the Outlook and Saskatoon sites were deep ripped and then rototilled to depth prior to planting while the Nipawin site was only disked and then lightly rototilled. As observed in 1997, there were no consistent differences in the taste or sweetness of the carrots between the three sites at the early harvest. At the final harvest, the carrots grown on dryland had a slightly higher average sugar content (° Brix) than the other sites. Drought stress tends to enhance the concentration of sugars in storage organs such as carrot roots.

Presto produced outstanding total yields at the early harvest, but grade out was such that its marketable yields were no better than the other test lines (Table CAR-1998-1). Similar results were obtained in the early harvest in 1997. At the final harvest, several of the Imperator types produced exceptionally high yields. The varieties tested were uniformly poor in terms of grade out at the final harvest.

Quality Characteristics

Contrary to expectations, taste of the crop did not improve from the 90 day harvest through to the final harvest at 120 days (Table CAR-1998-1). Although sugar content did increase with maturity, undesirable flavor characteristics such as bitterness also tended to increase as the crop matured. Some varieties maintained there flavor with maturity (Bolero, Earlibird Nantes, Presto) while in others flavor declined with time. Bolero and Presto had the best flavor profile of the varieties tested.

Carrots - 1999

Table CAR-1999-1. Yields and quality characteristics for carrots at two harvest dates and three production sites in Saskatchewan in 1999.

	Total (t/ha)		Marketable (t/ha)		Marketable (%)		Length (cm)		Taste (0-5)		Brix (%)	
	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d	90 d	120 d
Bolero	25.1	62.3	13.0	25.3	54.0	40.0	15.6	16.6	2.5	2.9	4.4	9.0
Carobest	15.8	48.2	9.5	14.4	57.0	26.0	21.6	21.1	1.8	2.5	4.6	7.2
Cheyenne	15.1	46.9	9.8	17.3	62.0	35.0	22.0	22.3	2.0	1.8	4.3	7.3
Choctaw	16.9	50.2	9.5	18.3	55.0	36.0	23.2	20.4	1.5	2.2	4.0	7.4
Eagle	18.4	51.1	11.1	24.2	56.0	42.0	19.3	18.7	2.1	1.8	5.4	8.0
Earlibird Nantes	23.2	57.7	13.0	24.6	55.0	40.0	14.1	13.8	2.3	1.9	5.5	8.0
Fontana	26.2	68.8	14.6	26.9	46.0	38.0	15.8	16.0	2.4	2.1	4.1	8.0
Idaho	32.4	68.3	19.1	31.4	55.0	43.0	17.2	17.2	2.1	2.3	4.6	7.4
Kamaran	30.1	70.4	17.8	32.2	54.0	43.0	15.2	15.5	2.6	2.4	5.3	8.5
Nandrin	25.3	70.7	12.8	26.5	48.0	33.0	15.5	16.8	2.0	2.8	4.9	7.7
Presto	28.3	61.9	15.4	27.3	52.0	39.0	15.1	14.9	3.1	2.0	4.5	7.2
Average	*23.3*	*59.8*	*13.2*	*24.2*	*54.0*	*38.0*	*17.7*	*17.6*	*2.2*	*2.2*	*4.7*	*7.8*
LSD	*11.3*	*21.0*	*8.3*	*14.8*	*13.0*	*13.0*	*1.8*	*3.1*	*0.6*	*0.6*	*0.9*	*1.0*
Nipawin Dryland	12.5	37.4	5.3	9.0	42.0	25.0	16.8	16.0	1.6	2.5	4.7	8.0
Nipawin Irrigated	19.0	43.7	10.0	16.9	52.0	37.0	16.2	15.7	2.7	2.3	5.0	7.2
Outlook	37.2	89.9	22.8	37.8	61.0	41.0	18.1	19.2	2.7	1.9	4.9	8.2
Saskatoon	24.6	68.3	14.8	33.6	61.0	50.0	19.4	19.5	1.9	2.3	4.0	7.7
LSD	*4.6*	*7.8*	*3.1*	*5.4*	*6.0*	*6.0*	*1.8*	*1.6*	*0.3*	*0.4*	*0.5*	*0.6*

Yields and quality characteristics of the various cultivars tested for the two harvests are presented in Table CAR-1999-1, along with data for the three test sites (averaged over cultivars). Cultivar performance at the individual test sites is presented in Appendices CAR-1999 A, B and C.

The yield patterns in 1999 were very similar to the 1998 trial. At the early harvest, total and marketable yields at the irrigated Outlook 3 were higher than the other irrigated sites. Grade out was moderate at the early harvest. At the final harvest, marketable yields for the Saskatoon and Outlook sites were comparable and were well above the provincial average of 20 t/ha. Final yields under dryland conditions in Nipawin were exceptionally poor with low yields combining with high levels of gradeout to abnormal shape. Problems with gradeout can be expected in situations where moisture supply is erratic. On average, the carrots were slightly longer in Outlook and Saskatoon than at both Nipawin sites. This likely reflects differences in the depth of tillage prior to planting. Both the Outlook and Saskatoon sites were deep ripped and then rototilled to depth prior to planting while the Nipawin site was only disked and then lightly rototilled. In 1997 and 1998, there were no consistent differences in the taste or sweetness of the carrots between the three sites at the early harvest. However, in 1999, the irrigated site at Nipawin and the Outlook site produced better tasting carrots at the first harvest than the other two trial sites. The Brix values obtained at the early harvest were exceptionally low - this may reflect the relatively immature state of the carrots at the early harvest. Carrots from the Saskatoon site had unusually low soluble solids content at the first harvest - this may have contributed to their perceived lack of flavour. At the final harvest, the carrots grown under irrigation in Nipawin had a slightly lower average sugar content (° Brix) than the other sites while the taste of the crop at the Outlook site was rated as inferior to the other sites.

The cultivars Idaho (new in 1999), Kamaran and Presto produced outstanding total yields at the early harvest. Grade out of Presto was such that its marketable yields at the first harvest were no better than the other test lines (Table CAR-1999-1). Similar results were obtained in the early harvest in 1997 and 1998. Yields of the Imperator type carrots were generally poor at the first harvest, however, by the final harvest, several of the Imperator types produced exceptionally high yields. The varieties tested were uniformly poor in terms of grade out at the final harvest.

Quality Characteristics

In previous trials, the taste of the crop did not improve from the 90 day harvest through to the final harvest at 120 days (Table CAR-1997-1 and CAR-1998-1). A similar trend was observed in 1999. Although sugar content did increase substantially with maturity, undesirable flavor characteristics such as bitterness also tended to increase as the crop matured. Some varieties maintained there flavor with maturity (Bolero, Carobest, and Nandrin) while in others (Earlibird Nantes and Presto)their flavor declined with time. Bolero and Kamaran had the best flavor profiles of the varieties tested. These varieties also had the highest Brix levels.

Summary for carrots (1997 -1999)

Yields of carrots varied considerably between test seasons and across the three sites examined in this trial. In large part, this reflects the growing condition characteristics of the sites and years. Management factors also contributed to the site to site and year to year variability. In all three test seasons, the irrigated sites produced the highest yields. Carrots are renowned for their sensitivity to moisture stress throughout the growing season. In 1997 and 1998, rainfall at the Nipawin dryland site was well below the requirements for carrots. This situation was exacerbated in 1998 by planting the dryland crop onto land which had been in crop in 1997. Summer fallowing is definitely recommended if carrots must be produced without irrigation. In 1999 there was more abundant rainfall but its seasonal distribution did not coincide with the key periods of sensitivity of the carrots crop (germination and root elongation). Quality of carrots was generally acceptable at all sites, although grade out due to defects in shape was high. Thorough site preparation prior to planting is crucial to development of long, uniform roots. There were no consistent differences in quality across the test sites.

This study has identified several high yielding cultivars of both Imperator and Nantes carrots with adequate consumer quality to be accepted in Saskatchewan's marketplaces. For even the best adapted cultivars a substantial grade out

n be expected - clearly, a markets for culls will be critical to the development of the carrot sector.

It should be noted that this trial did not evaluate several other factors which may determine the relative suitability of a given cultivar. Successful marketing of carrots hinges on effectively storing the crop. The storage characteristics of various carrot cultivars differ greatly - but were not evaluated in this trial. Mechanical harvesting is the norm for commercial carrot production. Carrot cultivars also vary in their tolerance to rough handling with many of the Nantes type carrots proving unsuited to mechanical harvest due to their extreme susceptibility to shattering. Growers must consider all factors in production and marketing when selecting an appropriate cultivar.

Cabbage trial

This trial evaluated earliness, yields and quality of cabbage produced at the three test sites in 1997, 1998 and 1999. Late maturing storage-type cultivars were selected as they represent the type of greatest interest to local processors. The cultivars were selected based on previous performance in University of Saskatchewan trials and the preference expressed by local processors (Delsa Foods, Deslisle SK). Direct seeding was compared to production utilizing 6 week old transplants. The transplants were produced by Nipawin Greenhouse in Nipawin in 1997 and by the Plant Sciences Department in 1998 and 1999.

Site Preparation

At all sites, the soil was initially disced to 8" to incorporate crop residues and the fertilizer. The plots in Outlook and Saskatoon were rototilled to produce uniform, smooth conditions and to incorporate the pre-plant applied herbicide. In 1997, a second discing was used for the same purpose in Nipawin, but the resulting seedbed was considerably rougher than the other sites. In 1998 and 1999, the Nipawin site was rototilled prior to seeding. Rototilling tends to accelerate moisture loss from the soil - this can be an undesirable side effect in situations where moisture supplies are limited.

Fertility

Fertilizers were applied at each site to raise N and P levels to provincial recommendations for cabbage (120 #/a N and 100#/a P2O5). All three sites tested higher than the provincial recommendation for K on cabbage.

Seeding/Transplanting

The direct seeded crop was planted in early May at all three sites using a push-type Precision Planter, equipped with a standard cabbage seeding disk. The crop was seeded ½" deep at the Saskatoon and Outlook sites where irrigation was available. At the Nipawin site, irrigation was not available at planting, so the seed was planted to moisture (1.5" deep). Twin rows of each cultivar were seeded 1 m apart in 8 m long rows replicated four times at each site (randomized complete block design). The six week old transplants were placed in adjacent plots at the same time. The transplants were irrigated in at all sites including the "dryland" plots in Nipawin.

Pest Management

The herbicide Treflan (trifluralin) was used prior to planting at all three sites. The herbicide provided adequate early season weed control at the Outlook and Saskatoon sites, but was less effective in Nipawin (likely a reflection of greater weed pressure in Nipawin). Hand weeding was used to minimize weed competition at all three sites.

A side band application of granular Furadan at planting time provided adequate early season flea beetle control in Outlook and Saskatoon. (Note: Furadan is not registered for use on vegetable cole crops). In 1997, flea beetles were a problem in Nipawin despite side banding of the systemic insecticide. Several early applications of Sevin were required to control the beetles in Nipawin in 1997. In 1998 and 1999, flea beetles were less of a problem as the spring weather in those years was cooler than in 1997. Looper pressure was heavy throughout the season at all sites in all three test seasons. Decis was sprayed at 10-14 day intervals beginning mid-July through to the end of the season for looper control. Looper damage reduced the quality of some of the early cabbage cultivars in 1997. Black rot (*Xanthomonas sp*) and *Schlerotinia* were present at low levels throughout the cabbage plots at all sites. Disease levels were insufficient to warrant concern in 1997 and 1998. However, in 1999, loses to *Schlerotinia* were substantial at all three sites. This may reflect a build up of inoculums over the three year test period and suggest the

ed for more attention to crop rotation.

Moisture Management

verhead irrigation was used to maintain soil water potentials above -40 kPa throughout the growing season. Irrigation occurred weekly, with an average of 1.5 cm applied/irrigation. In 1997, a total of 15 cm was applied at the askatoon and Outlook sites and 10 cm at Nipawin. Total rainfall received during the 1997 season was 26 cm which below the 30 year average for the Nipawin area. Rainfall was spotty from late June through early August in 1997. In 1998, a total of 18 cm was applied at the Saskatoon and Outlook sites and 10 cm in Nipawin. Rainfall was limited rom July through early September. There was abundant rain in September and October. In 1999 rainfall was undant from seeding through until mid-July. A total of 10 cm was applied at the Saskatoon and Outlook sites with only 6 cm in Nipawin. There was limited rain in September and October.

arvest

Heads were judged to be mature when firm and when the wrapper leaves were beginning to open at the top of the ead. The cabbage was harvested weekly through until mid-October by which time growth had effectively ceased. Heads were graded, weighed and measured. Density of the heads was evaluated on a scale of 0-5, with a score of 5 representing a very dense head.

Results - 1997

The averages for the main treatment variables (cultivar, transplanting and sites) for the 1997 cabbage trials are summarized in table CAB-1997-1. The results for the individual sites are presented in Appendices CAB-1997-A, B and C

Stand Establishment

When direct seeded, the eight cultivars tested produced relatively similar stands at the four test sites (Table CAB-1997-1). Balbro, Bravo, Cecile and Dynamo produced a full stand at all sites, while Masada produced an inferior stand at all sites. The average for stand establishment was similar at all sites. Averaged over the sites and cultivars, the direct seeded crop produced 86% stand, while transplanting produced a slightly higher stand (93%) (Table CAB-1997-1). It is noteworthy that the cultivar Masada also produced a poor stand when transplanted.

At the Nipawin site, stand establishment of the direct seeded and transplanted crops was not influenced by the irrigation variable (Table CAB-1997-1).

Date to 50% Harvest and % Final Harvest

Averaged over the cultivars and test sites, the transplanted crop reached the 50% harvest point 10 days earlier than the direct seeded crop (Table CAB-1997-1). By the final harvest in late October, 90% of the transplanted crop had matured at the three test sites, while 85% of the direct harvested crop had reached marketable size. The 1997 growing was exceptionally favorable, with a long open fall. In a shorter, cooler growing season a higher proportion of the direct seeded crop would be immature at the end of the season.

When the crop was direct seeded, the Saskatoon site produced the earliest yields, followed by the dryland site in Nipawin (Table CAB-1997-1). A similar degree of acceleration of crop maturity in Saskatoon was noted for the other cruciferous crops tested. In the transplanted crop, the time to 50% harvest was similar for the three test sites. In Saskatoon, 100% of the direct seeded crop matured before the end of the growing season, followed by the Outlook

site (93%). The two Nipawin sites lagged behind in terms of % of the crop maturing. A similar ranking of sites was observed in the transplanted crop. Irrigation had no impact on the rate of development of either the direct seeded or transplanted crops in Nipawin (Table CAB-1997-1).

Yields

Yields were exceptionally high at all sites. The average site yield (60 t/ha), exceeds the average published for Saskatchewan (20-30 t/ha) by a substantial margin. The yields can be attributed to the exceptional growing season coupled with a high level of management in this trial. Averaged over the sites and cultivars, the transplanted crop outyielded the direct seeded by 15% (Table CAB-1997-1).

Table CAB-1997-1. Growth and yields of eight cabbage cultivars at three sites in Saskatchewan in 1997.

	Stand %	Date of 50% Harvest	Final Harvest %	Yield (t/ha)	Head Density (0-5)	Head Wt (kg)
Balbro	100 a	Aug 24 d	100 a	63.5 b	3.5 b c	1.8 c
Bartolo	87 b	Oct 1 b	66 c	49.8 c	3.8 b c	2.0 d e
Bravo	100 a	Sept 5 c	96 a	69.3 a b	2.9 d	2.3 c d
Cecile	100 a	Sept 5 c	90 a b	76.3 a	4.1 a b	2.4 b c
Dynamo	100 a	Aug 25 d	100 a	44.8 c	4.6 a	1.1 c
Hinova	83 c	Sept 23 b	90 a b	64.4 b	3.6 b c	2.6 b
Lennox	90 b	Oct 1 b	85 b	60.8 b	3.9 b	2.3 c d
Masada	53 d	Oct 15 a	45 d	44.9 c	3.2 c d	3.1 a
Direct Seeded	86 a	Sept 21 a	82 b	55.4 b	3.5 b	2.1 a
Transplanted	93 a	Sept 8 b	87 a	64.4 a	3.9 a	2.2 a
Outlook	90%	Sept 21 a	94 a b	56.4 a	3.6	2.2 a
Saskatoon	100%	Sept 5 c	100 a	55.1 a	3.9	1.6b
Nipawin						
- Irrigated	100%	Sept 15 a b	78 c	62.2 a	3.6	2.2 a
- Dryland	90%	Sept 13 b	83 bc	59.0 a	3.9	2.1 a
Average	***95***	***Sept 14***	***89***	***58.3***	***3.8***	***2.0***

For each variable, values within columns followed by the same letter are not significantly different

Cecile was the highest yielding cultivar in both direct seeded and transplanted trials (Table CAB-1997-1). In the direct seeded trial, Balbro, Bravo and Hinova were also high yielding while Dynamo and Masada produced poor yields. When transplants were used, Lennox joined the previously mentioned cultivars in the high yielding category. Dynamo and Masada also produced poor yields when transplanted.

Production location had no significant effect on yields in either the transplanted or direct seeded trials (Table CAB-1997-1).

Head Characteristics

Head density and average head weight were similar in the transplanted and direct seeded crops (Table CAB-1997-1). This lack of difference is to be expected, as head size and density was used to determine harvest maturity. Relative head density and weight of the cultivars was also similar irrespective of whether they were transplanted or direct seeded (Table CAB-1997-1). Dynamo produced the densest heads followed by Cecile. Bravo and Masada produced low density heads. Masada produced the heaviest heads, followed by Hinova, while Balbro and Dynamo produced the lowest average head weight. For the direct seeded crops, head density was, on average, highest in Saskatoon and on dryland in Nipawin (Table CAB-1997-1). When the crop was transplanted, the irrigated plot at Nipawin produced the highest averaged head density, while the Outlook site produced the lowest density heads. Saskatoon had a lower average head weight than the other sites in the direct seeded trial. When the crop was transplanted, head weights were similar at all three test sites.

1998 Results

Table CAB-1998-1. Yields and head characteristics for direct seeded and transplanted cabbage at several sites across Saskatchewan in 1998.

	Stand %	Date to 50% Harvest	Yield (t/ha)	% Matured	Head Wt. (Kg)	Density (1-5)	Core/Head Ratio*
Bartolo	84	Oct. 21	37.6	62	1.9	3.7	0.54
Cecile	84	Sept. 12	55	75	2.3	3.9	0.42
Galaxy	66	Oct. 30	33.4	38	2.8	3	0.49
Green Start	89	Aug. 16	47	97	1.6	3.8	0.46
Hinova	88	Oct. 15	53.1	64	2.6	3.6	0.48
Lennox	84	Oct. 19	42.7	56	2.3	3.9	0.52
Parel	88	Aug. 19	40.4	95	1.4	3.7	0.48
Rio Verde	95	Sept. 20	62.6	88	2.3	3	0.54
Storage #4	95	Oct. 24	44.8	66	2.1	4.1	0.53
LSD	**9**	**11**	**10.2**	**14**	**0.3**	**0.3**	**0.02**
Direct Seeded	84	Oct. 6	42.7	69	2.2	3.7	0.49
Transplanted	88	Sept. 24	49.7	73	2.1	3.6	0.5
LSD	**4**	**5**	**4.8**	**6**	**0.1**	**0.1**	**0.01**
Nipawin Dryland	86	Oct. 22	22b	47b	1.6c	3.5b	.49b
Nipawin Irrigated	89	Sept. 28	51.8a	79a	2.3b	3.4b	.53a
Outlook	80	Sept. 13	59.6a	80a	2.5a	3.8a	.47c
Saskatoon	89	Sept. 21	57.6a	87a	2.3b	4a	.48bc
LSD	**6**	**8**	**7.2**	**10**	**0.2**	**0.2**	**0.01**
Average	**85**	**Oct 1**	**46.2**	**71**	**2.2**	**3.6**	**.50**

Stand Establishment

Stands in 1998 were not as complete as in 1997, with drought stress and caking of the soil surface causing problems with emergence at all sites. When direct seeded, the various cultivars tested produced relatively similar stands at the four test sites (Table CAB-1998-1). Rio Verde and Storage #4 produced excellent stands at all sites, while Galaxy produced an inferior stand at all sites. Averaged over the sites and cultivars, transplanting produced a slightly higher stand (88%) than direct seeding (84%)(Table CAB-1998-1). At the Nipawin site, stand establishment of the direct seeded and transplanted crops was not influenced by the irrigation variable (Table CAB-1998-1).

Date to 50% Harvest and % Final Harvest

Averaged over the cultivars and test sites, the transplanted crop reached the 50% harvest point 12 days earlier than the direct seeded crop (Table CAB-1998-1). By the final harvest in late October, 73% of the transplanted crop had matured at the three test sites, while 69% of the direct harvested crop had reached marketable size. In the previous season almost 90% of the crop had matured prior to the end of the season. The 1998 growing was still exceptionally favorable, with a long open fall. In a shorter, cooler growing season a higher proportion of the direct seeded crop would be immature at the end of the season. The rate of crop maturity was Outlook > Saskatoon > Nipawin irrigated > Nipawin dryland. Yields in the dryland site in Nipawin were saved by abundant late season rains coupled with a long open fall

Yields

Yields were again exceptionally high at all sites. The average site yield (> 40 t/ha), exceeds the average published for Saskatchewan (20-30 t/ha) by a substantial margin but was not as high as the yields obtained in 1997 (60 t/ha). The high yields can be attributed to the exceptional growing conditions in 1997 and 1998 coupled with a high level of management in this trial.

Averaged over the sites and cultivars, the transplanted crop outyielded the direct seeded by 15% in 1997 (Table CAB-1997-1) and by 16% in 1998.

Cecile and Rio Verde were the highest yielding cultivars in both direct seeded and transplanted trials (Table CAB-1998-1). Galaxy produced exceptionally low yields - a reflection of a poor stand coupled with its requirement for a very long growing season. When the crop was irrigated, production location had no significant effect on yields in either the transplanted or direct seeded trials (Table CAB-1998-1). Drought stress reduced yields dramatically (Nipawin-dryland)

Head Characteristics

In both years, head density and average head weight were similar in the transplanted and direct seeded crops (Table CAB-1997-1 and CAB-1998-1). This lack of difference is to be expected, as head size and density was used to determine harvest maturity. Relative head density and weight of the cultivars were also similar irrespective of whether they were transplanted or direct seeded (Table CAB-1997-1 and CAB-1998-1). In 1998, Cecile, Lennox and Storage #4 produced the densest heads. Galaxy and Rio Verde produced low density heads. Rio Verde is a very early maturing line - low head density is to be expected in early cabbage. The low head density in Galaxy reflects the need to harvest it prior to maturity. For the direct seeded crops, head size and density were, on average, higher in Saskatoon and Outlook than in Nipawin (Table CAB-1998-1).

In cabbage, a low ratio of core size to head size is desirable as the core is effectively waste. Cecile was outstanding

in this characteristic.

1999 Results

Table CAB-1999-1. Yields and head characteristics for direct seeded and transplanted cabbage at several sites across Saskatchewan in 1999.

	Stand %	Date to 50% Harvest	Yield (t/ha)	% Matured	% Diseased	Head Wt. (Kg)	Density (1-5)	Core/Head Ratio*
Almanac	84	251	121.4	95	17	4.1	3.0	0.45
Cecile	90	270	102.4	82	11	3.7	3.7	0.52
Greenstart	88	230	69.8	99	42	2.3	3.5	0.50
Hinova	92	286	66.1	58	3	3.2	3.7	0.57
Lennox	86	286	62.4	71	7	2.8	4.2	0.59
Little Rock	93	275	82.5	80	6	2.9	2.9	0.56
Ontario	85	291	41.7	47	2	2.9	4.1	0.56
Storage #4	92	290	51.3	58	2	2.6	4.2	0.61
Transam	89	286	65.5	64	7	3.2	3.3	0.60
Vantage	89	283	82.7	74	14	3.6	3.6	0.60
Zenith	89	249	86.5	96	26	2.8	3.2	0.45
Average	**89**	**272**	**75.7**	**75**	**13**	**3.1**	**3.6**	**0.54**
LSD	**16**	**10**	**21.8**	**15**	**10**	**0.5**	**0.5**	**0.02**
Direct Seeded	100	284	44.7	55	10	2.6	3.2	0.55
Transplanted	75	261	106.5	94	15	3.6	3.9	0.55
LSD	**4**	**6**	**7.4**	**6**	**5**	**0.2**	**0.2**	**0.02**
Nipawin Dryland	80	273	66.2	74	17	2.9	3.5	0.55
Nipawin Irrigated	87	270	81.0	76	16	3.3	3.4	0.55
Outlook	94	268	69.9	72	7	2.9	3.7	0.54
Saskatoon	94	278	85.7	78	9	3.2	3.7	0.55
LSD	**8**	**8**	**14.7**	**10**	**7**	**0.3**	**0.3**	**0.02**

Stand Establishment

Favorable conditions at planting time resulted in excellent stands at all sites in 1999. Despite abundant spring rainfall, the advantage of having irrigation during stand establishment are apparent as the dryland site produced a poorer stand than any of the irrigated sites. It is noteworthy that the direct seeded crop produced a more complete stand than when transplants were used. As previously noted, conditions at seeding time were nearly ideal in 1999, resulting in excellent stand establishment in the direct seeded crop. The fact that the direct seeded crop was overseeded and then thinned helped insure stand establishment. Some loss of transplants is common due to transplanting stress and wind damage. When direct seeded, the various cultivars tested produced relatively similar stands at the four test sites (Table CAB-1999-1).

Date to 50% Harvest and % Final Harvest

Averaged over the cultivars and test sites, the transplanted crop reached the 50% harvest point almost three weeks earlier than the direct seeded crop (Table CAB-1999-1). By the final harvest in late October, 94% of the transplanted crop had matured at the three test sites, while only 55% of the direct harvested crop had reached marketable size. The final maturity levels in the direct seeded crop were lower in 1999 than in the previous two years (90% in 1997 and 69% in 1998). The previous two seasons had been exceptionally warm with long open falls. In shorter, cooler growing seasons more typical of Saskatchewan a higher proportion of the direct seeded crop would be immature at the end of the season.

The rate of crop development at the Saskatoon site was significantly slower than fore the other two irrigated sites. There was a very large range in the maturity rate of the various cultivars tested. Greenstart, Almanac and Zenith can all be classified as "early" types - with over the half of the crop harvested prior to mid-September. Virtually all of the crop for the early varieties matured prior to the end of the trial. Cecile and Little Rock can be classified as mid-season types - with 50% of the crop ready for harvest by early October. For these cultivars about 80% of the crop reached marketable size by the end of the season. The remainder of the varieties are "late season" - with less than 60%f the crop maturing prior to the end of the season.

Yields

Yields were again exceptionally high at all sites. The average site yield (> 75 t/ha), exceeds the average published for Saskatchewan (20-30 t/ha) by a substantial margin and was higher than the yields obtained in 1997 (60 t/ha) and 1998 (40 t/ha). The high yields can be attributed to the uniformly favorable growing conditions in 1999 with abundant rainfall coupled with steady moderate temperatures.

Averaged over the sites and cultivars, the transplanted crop outyielded the direct seeded by 15% in 1997 (Table CAB-1997-1) by 16% in 1998 (Table CAB-1998-1). In the 1999 trial, the advantage of transplanting was much more substantial (ca 135%)(Table CAB 1999-1). This yield advantage reflects the importance of transplanting as a means for insuring crop maturity prior to the end of the growing season. It is particularly noteworthy that the yield advantage of transplanting occurred despite the superior stand produced by direct seeding.

Cecile and Almanac were the highest yielding cultivars in both direct seeded and transplanted trials (Table CAB-1999-1). The high yields for these varieties can be primarily attributed to the fact that virtually all of the heads matured prior to the end of the season. They also produced fairly large and dense head with a high percentage of the heads being marketable. By contrast, many of the late cultivars produced low yields - simply because a large portion of the crop never reached marketable size.

The Saskatoon site produced the highest yields followed by the irrigated site in Nipawin. Due to the relatively abundant rainfall in 1999, the Nipawin dryland site produced yields which were comparable to the some of the irrigated sites. The Outlook site produced relatively low yields, with a significant portion of the crop failing to reach marketable size at this site.

Head Characteristics

In previous trials, head density and average head weight were similar in the transplanted and direct seeded crops (Table CAB-1997-1 and CAB-1998-1). However in 1999 the transplanted crop produced larger, denser heads than when the crop was direct seeded. This again reflects the maturity advantage provided by transplanting particularly in a shorter growing season. Relative head density and weight of the cultivars were also similar irrespective of whether they were transplanted or direct seeded (Table CAB-1997-1, CAB-1998-1 and CAB-1999-1). In 1999, Lennox, Ontario and Storage #4 produced the densest heads. These are all very late cultivars. Cecile is both early and produced a fairly dense head. Average head size and density were quite similar for the various production sites in 1999 (Table CAB-1999-1).

In cabbage, a low ratio of core size to head size is desirable as the core is effectively waste. Core to head size ratios were similar for the various production sites and were not influenced by use of transplants. As in past years, the cv. Cecile produced a relatively small core, as did Zenith, Almanac and Greenstart.

Conclusions from the Cabbage Trial

Cabbage is a robust crop well adapted to cool, moist growing seasons. Cabbage yields are a function of stand and head size/density at harvest. Head size and density increase with time in the field until the maximum size and density for the cultivar is reached. The heads tend to split if left in the field too long. Rate of growth of cabbage increases with temperature within the optimum range for the crop (17-21 °C). High temperatures will accelerate maturity and increase yields in regions with a short season. Drought stress slows development of the cabbage crop, which will depress yields in slow maturing cultivars or at sites with a short growing season.

Transplanting versus Direct Seeding

The North American industry is moving to the use of transplants in cabbage production as it is perceived that transplanting provides one or all of the following advantages in cabbage production; a) lower seed costs, b) superior stand establishment (% and uniformity), c) early yields, d) higher yields, e) better quality. These advantages come with the considerable added cost of producing or purchasing the transplant ($0.02-0.08 apiece).

In this study, the direct seeded crop was overseeded by 100% in an attempt to ensure a quality stand. At present, this is a common approach. However as seed costs rise and the labor to thin overseeded crops becomes more expensive, growers are increasingly questioning the viability of this practice. In this study, the quality of the stand produced by direct seeding depended on the cultivar and the year. In most situations, overseeding by a factor of 50% resulted in an effectively complete stand. In two out of three test years, transplanting still produced a better stand than direct seeding. This reflects the challenges encountered in getting good emergence under unpredictable field conditions. Emerging seedlings are also very susceptible to attack by insect pests such as flea beetles. By contrast, transplants are more robust, especially as their transplanting can be delayed until field conditions are more favorable. The larger transplants are also better able to tolerate attack by insects than developing seedlings.

Yields were earlier (10 days to three weeks) and more complete (10-40%) for the transplanted crop, with actual

ields increased by 15-130% in the transplanted crop. Depending on the year annd the variety, the yield increase with transplanting reflects; a) an improved stand, b) increased head size and density and c) a greater proportion of the ransplanted crop maturing prior to the end of the growing season. The long favorable growing season experienced in th 1997 and 1998 tended to minimize differences between direct seeded and transplanted crops. In the more typical growing season experienced in 1999, benefits of transplanting were more dramatic.

abbage Cultivars

n cabbage, consistent seedling vigor, high yields and head quality are the primary considerations in cultivar election. Earliness may be desirable when producing for the fresh market but is not a real concern in a storage crop. Head density is a good indicator of storage potential. Processors are also seeking dense headed lines as they reduce the onsite storage requirements. Several of the cultivars tested proved good to exceptional for several of these arameters. The performance of the superior cultivars was relatively uniform across the four test sites. This allows a considerable degree of confidence when making cultivar selections. One cultivar, Cecile, was outstanding in all categories. It showed excellent seedling vigor, with early maturity, high yields and acceptable head density in all hree test years. It also had one of the lowest core:head ratio of the varieties tested. Balbro, Bravo and Hinova 1997), Rio Verde (1998) and Almanac and Zenith (1999) were all nearly equivalent to Cecile in seedling vigor, yields and earliness but were substantially inferior to Cecile in density. Dynamo (1997), Parel (1998), Storage #4 and Ontario produced very dense heads, but either these varieties were very late or their heads were small and yields were oor. **The standard cultivar Lennox was not outstanding in any of the performance categories evaluated.**

ites:

The sites were selected to present a range of sites where cabbage could be produced in central Saskatchewan. As noted on p 1, the sites were quite different in soil type, availability of shelter and supplemental irrigation. As noted n tables 1-3 there were also substantial differences in temperatures and frost free season length between the two southern sites and the Nipawin site. Each site had aspects which should promote growth of the crop but other aspects which may have been detrimental. ***In 1997 and 1999, there were few significant differences between the four test sites for any of the performance, yield or quality parameters examined in this cabbage trial.*** It appears that the positive and negative factors associated with each site balanced one another out in these two seasons. In 1998, the two sites with abundant available irrigation (Outlook and Saskatoon) were the highest yielding while the dryland site in Nipawin produced poorly. The 1998 cropping season was exceptionally dry until the fall. It is noteworthy that the average seasonal precipitation for the Nipawin area is 30 cm - indicating the site is well suited to the production of cabbage without irrigation, providing that the precipitation events coincide with the requirements of the crop. The Nipawin site is in a low sheltered spot, adjacent to the North Saskatchewan River. The site receives very heavy dews, which runs off the waxy leaves of the cabbage to the soil. The combination of shelter, high R.H. and low temperatures characteristic of the Nipawin site would have minimized moisture loss from the crop and the soil - thereby reducing total crop moisture requirements relative to other sites. The aggressive weed management practised at all sites would help conserved the available moisture for use by the crop under dryland conditions.

	Positive	Negative
Outlook		
Sandy soil	Good stand establishment	Low late season fertility
Warm temperatures	Fast crop growth	Drought stress
	Irrigated	Exposed site
Saskatoon		
Clay soil	Fertilizer + moisture retention	Poor stand establishment
	Sheltered, heavily managed, irrigated site	
Nipawin		
Silt soil	Good for stand establishment + fertility retention	
Cool	Slow crop growth	Reduce crop moisture loss
Shelter	Sheltered site	

Broccoli

This trial evaluated earliness, yields and head quality of broccoli produced at the three test sites. The cultivars were selected for trialing based on past performance in University trials. A range of maturity dates were also sought in the cultivars selected.

Site Preparation

At all sites, the soil was initially disced to 8" to incorporate crop residues and the fertilizer. The plots in Outlook and Saskatoon were then rototilled to produce uniform, smooth conditions and to incorporate the pre-plant applied herbicide. In 1997, a second discing was used for the same purpose in Nipawin. The resulting seedbed in 1997 at the Nipawin site was considerably rougher than the other sites. In 1998 and 1999, the Nipawin site was rototilled prior to seeding. Rototilling tends to accelerate moisture loss from the soil - this can be an undesirable side effect in situations where moisture supplies are limited.

Fertility

Fertilizers were applied at each site to raise N and P levels to provincial recommendations for broccoli (120 #/a N and 100#/a P2O5). All three sites tested higher than the provincial recommendation for K on broccoli. The crop was seeded in early May at all three sites using a push-type Precision Planter, equipped with a standard broccoli seeding disk. The crop was seeded ½" deep at the Saskatoon and Outlook sites where irrigation was available. At the Nipawin site, irrigation was not available at planting, so the seed was planted to moisture (1.5" deep). Twin rows of each cultivar were seeded 0.75 m apart in 8 m long rows. This trial was not replicated.

Pest Management

The herbicide Treflan (trifluralin) was used prior to planting at all three sites. The herbicide provided adequate early season weed control at the Outlook and Saskatoon sites, but was less effective in Nipawin (likely a reflection of greater weed pressure in Nipawin). Hand weeding was used to minimize weed competition at all three sites. A side band application of granular Furadan at planting time provided adequate early season flea beetle control in Outlook and Saskatoon during all three test seasons. In 1997, flea beetles were a problem in Nipawin despite side banding of the insecticide. Several early applications of Sevin were required to control the beetles in Nipawin. Flea beetles were less of a problem in 1998 and 1999. Looper pressure was moderately heavy throughout the season at all sites in all three test years. Decis was sprayed at 10-14 day intervals beginning mid-July through to the end of the season for looper control. Looper damage had little impact on the broccoli crop.

Moisture Management

Overhead irrigation was used to maintain soil water potential above -40 kPa through the growing season at the Outlook and Saskatoon sites. Irrigation occurred weekly, with an average of 1.5 cm applied/irrigation. A total of 15 cm was applied at the Saskatoon and Outlook sites and 10 cm at Nipawin. Half of the Nipawin site was left non-irrigated. Total rainfall received during the 1997 season was 19 cm which is below the 30 year average for the Nipawin area. Rainfall was spotty from late June through early August in 1997. In 1998, total rainfall from May-August was only 10 cm which is far below the seasonal average. In 1999 rainfall was abundant from seeding through until mid-July. A total of 10 cm of irrigation was applied at the Saskatoon and Outlook sites with only 6 cm applied in Nipawin. There was limited rain in September and October.

Harvest

The broccoli was judged to have reached harvest maturity once the head reached full size but before the head began to open. The broccoli was harvested weekly through until mid-October by which time growth had effectively ceased. Heads were graded, weighed and measured.

RESULTS for 1997

The summary data obtained for the 1997 broccoli trial are presented in Table BRO-1997-1. The results for the individual trial sites are presented in Appendices BRO-1997 - A,B,C,D.

Table BRO-1997-1. Growth characteristics, yields and head quality for broccoli grown at three sites in Saskatchewan in 1997.

	% Stand	Date of 50% Harvest	Yield (t/ha)	% Hollow	Interleaf (%)	Head Diameter (cm)
Outlook	86a	Aug 19 ab	31.8a	21	20	18.8
Saskatoon	47b	Aug 17 b	20.9b	15	43	16.8
Nipawin						
Irrigated	53b	Aug 24 ab	15.0bc	21	12	17.8
Dryland	40b	Aug 31 a	7.9c	3	3	15.2
LSD 0.05	**16**	**14**	**9**	**11**	**17**	**2.9**
Arcadia	55	Aug 30 a	19.1	14	18	18.2
Early Dividend	46	Aug 7 b	11.3	21	18	15
Emerald City	64	Aug 25 a	21.2	8	14	16.6
Marathon	64	Sept 2 a	25.6	24	23	18.8
Patriot	58	Sept 2 a	21.8	14	29	17.6
LSD 0.05	**35**	**10**	**17.2**	**17**	**32**	**3.8**

Values within columns followed by the same letter are not significantly different

Stand establishment

The desired in-row spacing for broccoli under irrigation is 30 cm. The seeder disc used in this trial actually plants at 15 cm intervals to compensate for anticipated problems with emergence. Stand % were evaluated based on this 15 cm spacing. The stand in Outlook was superior to the other test sites (Table BRO-1997-1). The Outlook site features a light soil with irrigation available at seeding. This combination of features is required for optimal germination of small seeded cruciferous crops. By contrast, the soil in Saskatoon was too heavy while the lighter Nipawin site could not be irrigated until well after crop emergence. With 50% emergence, the stand at the Saskatoon and Nipawin sites was still acceptable because of the initial overseeding. Nonetheless, the practice of overseeding is costly in terms of wasted seed and the requirement for thinning. Planting to stand is a more efficient practice, but this approach must be coupled to effective site preparation and early season moisture management.

All of the broccoli cultivars tested produced an acceptable stand if overseeded at a 2:1 rate (Table BRO-1997-1). There were no differences in % stand between the cultivars.

Time to 50% Harvest

The broccoli crop matured, on average, most rapidly in Saskatoon (Table BRO-1997-1). This likely reflects the increased level of crop management available at the "home" site. The dryland plot in Nipawin was slowest to mature - drought stress is known to slow the development of cruciferous vegetables. The cultivars tested matured over a four week period. This variability in maturity may be desirable as it would allow a continuous supply of product based on a single planting date.

Yields

The average yield (18.9 T/ha) was well in excess of provincial averages reported by AB for irrigated broccoli (10 t/ha). Yields in Outlook were substantially higher than any other site (Table BRO-1997-1). This is probably a function of the superior stand established in Outlook coupled with the fact that the crop was only lightly thinned. The fact that a higher than recommended plant population resulted in superior yields probably reflects the near optimal growing season and management practices available in Outlook. Yields at the Nipawin site were substantially lower than the more southerly trial site. Yields on dryland were roughly 50% of those under irrigation at the Nipawin site (Table BRO-1997-1).

Large site to site variability obscured the differences between yields of the various cultivars. The earliest cultivar (Early Dividend) produced inferior yields relative to the later types (Table BRO-1997-1).

Head Characteristics

The dryland site at Nipawin produced relatively small but high quality heads which were not as prone to quality defects as at the other sites (Table BRO-1997-1). The superior quality coming from the dryland plots did not compensate for the low yields produced on dryland.

None of the cultivars was outstanding in terms of head quality - Marathon and Early Dividend had a higher than desired amount of hollowstem, while interleafing was severe in Patriot.

RESULTS for 1998

The summary data obtained for the 1998 broccoli trial are presented in Table BRO-1998-1. The results for the individual trial sites are presented in Appendices BRO-1998 - A,B,C,D.

Table BRO-1998-1. Growth characteristics, yields and head quality for broccoli grown at three sites in Saskatchewan in 1998.

					Head Characteristics			
	% Stand	Date Of 50% Harvest	% Harvested	Yield (t/ha)	% Hollow	% Interleaf	Head Diam (cm)	Head Wt (kg)
Captain	90	233	47	10.9	11	6	17	0.29
Emerald	100	240	55	15.5	3	20	16	0.34
Everest	100	234	75	12.5	0	11	19	0.22
Marathon	72	251	38	12.2	27	39	16	0.42
Patriot	100	253	53	15.7	6	46	16	0.37
Mean	*92*	*242*	*54*	*13.3*	*10*	*24*	*17*	*0.32*
LSD	**21**	**15**	**27**	**6.4**	**12**	**28**	**7**	**0.06**
Nipawin Dryland	52	245	28	4.7	7	8	19	0.25
Nipawin Irrigated	100	245	73	15.0	17	8	15	0.27
Outlook	100	230	61	16.5	8	36	18	0.36
Saskatoon	100	230	52	17.2	5	45	15	0.42
LSD	**44**	**13**	**24**	**5.7**	**11**	**25**	**6**	**0.06**

Values within columns followed by the same letter are not significantly different

Stand establishment

The desired in-row spacing for broccoli under irrigation is 30 cm. The seeder disc used in this trial actually plants at 15 cm intervals to compensate for anticipated problems with emergence. Stand % were evaluated based on this 15 cm spacing. All three irrigated sites had virtually complete stands but stands were reduced under dryland conditions in Nipawin (Table BRO-1998-1). It is noteworthy that the dryland site used in Nipawin had been cropped the previous season. Summer fallowing may be necessary for stand establishment under non-irrigated conditions. With 50% emergence, the stand for the dryland plots in Nipawin was still acceptable because of the initial overseeding. Nonetheless, the practice of overseeding is costly in terms of wasted seed and the requirement for thinning. Planting

stand is a more efficient practice, but this approach must be coupled to effective site preparation and early season moisture management.

l of the broccoli cultivars tested produced an acceptable stand if overseeded at a 2:1 rate (Table BRO-1998-1). Marathon produced a poorer stand than the other varieties tested.

me to 50% Harvest

The broccoli crop matured, on average, most rapidly in Saskatoon and Outlook (Table BRO-1998-1). This likely flects more intensive moisture management at these sites than in Nipawin. Contrary to the results obtained in 97, in 1998 the crop under dryland conditions in Nipawin matured at the same time as the irrigated crop. The cultivars tested matured over a three week period. This variability in maturity may be desirable as it would allow a ntinuous supply of product based on a single planting date.

Yields

he average yield (13 T/ha) was lower than the yields for 1997 but were still in excess of provincial averages reported by AB for irrigated broccoli (10 t/ha). A significant proportion of the crop failed to mature prior to the end of the season in 1998. Yields at the three irrigated sites were very comparable, while yields under dryland conditions ere poor (Table BRO-1998-1). The poor yields in the dryland trials is related to ; 1) a poor initial stand, 2) slow maturity and 3) small average head size. Patriot and Emerald were the highest yielding lines tested.

lead Characteristics

Each site produced head with different visual characteristics. On average, the heavily irrigated sites (Saskatoon and Outlook) produced larger heads with little hollow stem but more interleafing than the Nipawin sites (Table BRO-1998-1). In 1997, the dryland site had produced small but exceptionally high quality heads. The more extreme moisture stress in 1998 resulted in very poor head quality in the dryland trials.

None of the cultivars was outstanding in terms of head quality - Marathon had a higher than desired amount of hollowstem, while interleafing was severe in Emerald, Patriot and Marathon.

RESULTS for 1999

The summary data obtained for the 1998 broccoli trial are presented in Table BRO-1998-1. The results for the individual trial sites are presented in Appendices BRO-1998 - A,B,C,D.

Table BRO-1999-1. Growth characteristics, yields and head quality for broccoli grown at three sites in Saskatchewan in 1999.

				Head Characteristics			
	% Stand	Date Of 50% Harvest	Yield (t/ha)	% Hollow	% Interleaf	Head Diam (cm)	Head Wt (kg)
Arcadia	96	241	21.1	20	12	16.0	0.278
Captain	100	225	21.1	27	8	15.9	0.224
Emerald	100	236	23.6	21	20	14.2	0.300
Emperor	98	232	20.1	38	10	12.7	0.267
Marathon	100	240	29.0	51	19	16.6	0.367
Mariner	88	238	19.8	38	17	12.6	0.303
Patriot	100	240	27.1	22	29	14.7	0.310
Mean	*96*	*236*	*23.2*	*31*	*17*	*14.6*	*0.296*
LSD	**8**	**6**	**11.6**	**29**	**17**	**2.4**	**0.100**
Nipawin Dryland	93	239	16.6	21	12	13.8	0.237
Nipawin Irrigated	100	232	23.6	35	16	14.3	0.278
Outlook	100	239	27.6	18	22	16.1	0.335
Saskatoon	99	236	25.6	50	17	14.5	0.337
LSD	**6**	**6**	**7.5**	**18**	**14**	**2.1**	**0.067**

Values within columns followed by the same letter are not significantly different

Stand establishment

The desired in-row spacing for broccoli under irrigation is 30 cm. The seeder disc used in this trial actually plants at 15 cm intervals to compensate for anticipated problems with emergence. Stand % were evaluated based on this 15 cm spacing. All three irrigated sites had virtually complete stands but stands were reduced under dryland conditions

Nipawin (Table BRO-1999-1). A similar effect was observed in the 1998 trial. It is noteworthy that the dryland site used in Nipawin had been cropped the previous season. Summer fallowing may be necessary for stand establishment under non-irrigated conditions. The stand for the dryland plots in Nipawin was still acceptable because of the initial overseeding. Nonetheless, the practice of overseeding is costly in terms of wasted seed and the requirement for thinning. Planting to stand is a more efficient practice, but this approach must be coupled to effective site preparation and early season moisture management.

All of the broccoli cultivars tested produced an acceptable stand if overseeded at a 2:1 rate (Table BRO-1999-1). Mariner produced a poorer stand than the other varieties tested. The problems with stand establishment observed with the cv. Marathon in the 1998 trial were not repeated in 1999.

Time to 50% Harvest

The rate at which the broccoli crop matured was similar at the four test sites (Table BRO-1999-1). This likely reflects the relatively abundant and uniform moisture available during the 1999 cropping season. In previous years, drought stress had delayed maturity of the crop at the dryland Nipawin site. The cultivars tested matured over a two week period. This variability in maturity may be desirable as it would allow a continuous supply of product based on a single planting date. The cv. Captain tested for the first time in the 1999 trial was exceptionally early.

Yields

The average yield (23 T/ha) was higher than either of the previous test years - this can be largely attributed to the excellent yields obtained at both of the Nipawin sites in 1999. A significant proportion of the crop failed to mature prior to the end of the season in 1998. Yields at the three irrigated sites were very comparable, while yields under dryland conditions were slightly lower (Table BRO-1999-1). The poor yields in the dryland trials in 1999 were related to ; 1) a slightly poorer initial stand, and 2) small average head size. Marathon, Patriot and Emerald were the highest yielding lines tested.

Head Characteristics

As in the previous years of testing, each site produced head with different visual characteristics. On average, the heavily irrigated sites (Saskatoon and Outlook) produced larger heads than the Nipawin sites (Table BRO-1999-1). In 1997, the dryland site had produced small but exceptionally high quality heads. The more extreme moisture stress in 1998 resulted in very poor head quality in the dryland trials. In 1999, the dryland site produced relatively small heads with an average incidence of defects such as interleafing or hollow stem.

None of the cultivars was outstanding in terms of head quality. Marathon, Mariner and Emerald had a higher than desired amount of hollowstem. Hollowstem is related to rapid growth and these varieties were all exceptionally high yielding. Interleafing was severe in Patriot and Marathon.

Summary for the Broccoli Trial

When rainfall or irrigation adequate to insure stand establishment and crop growth, yields and quality of the broccoli crop generated at all three sites were excellent in this series of trials. Drought stress is clearly undesirable in broccoli production and irrigation is highly recommended as an insurance measure. Although several of the cultivars tested produced acceptable yields of marketable product, none was outstanding in all aspects of yields and quality. Growers should grow at least two cultivars to stagger the harvest, reduce yield risk and insure acceptable market quality.

Attention to flea beetle control is required early in the season when broccoli is established from seed. Transplanting may reduce problems with early season beetle damage. Labor requirements for harvest are significant in this sequentially harvested crop. The capital and operating costs involved in Slush icing of the crop also represents an impediment to growers.

auliflower

This trial evaluated earliness, yields and head quality of cauliflower produced at the three test sites in 1997, 1998 and 999. The cultivars were selected for the trial based on past performance in University trials. A range of maturity ates were also sought in the cultivars selected. In general, self blanching varieties were used as they represent the industry standard.

ite Preparation

t all sites, the soil was disced to 8" to incorporate crop residues and the fertilizer. The plots in Outlook and askatoon were then rototilled to produce uniform, smooth conditions and to incorporate the pre-plant applied herbicide. In 1997, a second discing was used for the same purpose in Nipawin, but this produced a seedbed which as considerably rougher than the other sites. In 1998 and 1999, the Nipawin site was rototilled prior to planting. ototilling tends to accelerate moisture loss from the soil - this can be an undesirable side effect in situations where moisture supplies are limited.

ertility/planting

Fertilizers were applied at each site to raise N and P levels to provincial recommendations for cauliflower (75 #/a N nd 100#/a P2O5). All three sites tested higher than the provincial recommendation for K on cauliflower. The crop as seeded in early May at all three sites using a push-type Precision Planter, equipped with a standard cauliflower seeding disk. The crop was seeded ½" deep at the Saskatoon and Outlook sites where irrigation was available. At he Nipawin site, irrigation was not available at planting, so the seed was planted to moisture (1.5" deep). Twin rows f each cultivar were seeded 0.75 m apart in 8 m long rows. In 1997 and 1999, 4 week old transplants were used to establish another series of plots for comparison with the direct seeded trial. This trial was not replicated.

est Management

The herbicide Treflan (trifluralin) was used prior to planting at all three sites. The herbicide provided adequate early eason weed control at the Outlook and Saskatoon sites, but was less effective in Nipawin (likely a reflection of greater weed pressure in Nipawin). Hand weeding was used to minimize weed competition at all three sites. A side band application of granular Furadan (not registered for use in vegetable cole crops) at planting time provided dequate early season flea beetle control in Outlook and Saskatoon. In 1997, flea beetles were a problem in Nipawin despite side banding of the insecticide. Several early applications of Sevin were required to control the beetles in Nipawin in 1997. Looper pressure was heavy throughout the season at all sites in 1997 and 1998 but were less of a roblem in 1999 due to the cooler growing season. Decis was sprayed at 10-14 day intervals beginning mid-July hrough to the end of the season for looper control. Looper damage had no impact on yields or quality of the cauliflower crop at any of the test sites.

Moisture Management

Overhead irrigation was used to maintain soil water potentials above -40 kPa through the growing season. Irrigation occurred weekly, with an average of 1.5 cm applied/irrigation. A total of 15 cm was applied at the Saskatoon and Outlook sites and 10 cm at Nipawin. Half of the Nipawin site was left non-irrigated. In 1997, total rainfall received during the season was 26 cm which is slightly below the 30 year average for the Nipawin area. Rainfall was spotty from late June through early August in 1997. The 1998 cropping season was exceptionally dry from May through August (10 cm total ppt), but rainfall was abundant in September and October. In 1999 rainfall was abundant from seeding through until mid-July. A total of 10 cm of irrigation was applied at the Saskatoon and Outlook sites with

only 6 cm applied in Nipawin. There was limited rain in September and October.

Harvest

No attempt was made to blanch the crop as all the lines trialed were self blanching. The cauliflower crop was judged to have reached marketable maturity when the heads reached a minimum diameter of 15 cm but before the heads began to open up. The cauliflower was harvested weekly through until mid-October by which time growth had effectively ceased. Heads were graded, weighed and measured.

RESULTS for 1997

The results obtained for the cauliflower trial in 1997 are outlined in table CAUL-1997-1. Data for the individual trial sites are presented in Appendices CAUL - 1997-A, B, C, and D.

Table CAUL-1997-1. Stand, yield and head quality characteristics for Cauliflower grown at several sites in Saskatchewan in 1997.

	% Stand	Date of 50% Harvest	Yield (t/ha)	% Hollow	Interleaf (%)	Head Diameter (cm)	Head Weight (kg)
Outlook	60c	Sept 12b	28.0a	10	10	18.7a	1.24a
Saskatoon	80ab	Aug 19a	25.3a	12	9	14.5b	0.64b
Nipawin							
Irrigated	66bc	Sept 7b	23.3a	1	0	14.5b	0.71b
Dryland	100a	Sept 9b	19.1b	0	1	14.5b	0.39c
LSD 0.05	**24**	**13**	**5.5**	**9**	**7**	**2.6**	**0.24**
Cashmere	62	Sept 1 ab	19.9	6	14	14.5	0.8
Early Dawn	100	Aug 25 a	24.9	0	1	15.5	0.5
Incline	61	Sept 25 b	23.7	8	5	14	0.88
Minuteman	88	Aug 27 a	28.4	1	5	16.5	0.68
Rushmore	78	Sept 2 ab	25.4	1	4	15.9	0.66
Serrano	68	Sept 5ab	23.1	16	4	17.1	0.76
Yukon	59	Sept 7 ab	22.2	7	2	15.6	0.94
LSD 0.05	**36**	**19**	**8.6**	**13**	**11**	**4.5**	**0.6**

tand establishment

Stand establishment is notoriously difficult in cauliflower as the emerging seedlings are small, slow growing and one to drought and attack by flea beetles. All test plots were overseeded by 50% in anticipation of problems with and establishment. Despite this precaution, stand establishment was poor in Outlook (Table CAUL-1997-1). These results are puzzling as the site featured the light soil favored for rapid emergence of cauliflower. Moisture vailability should not have been a problem as the Outlook site was irrigated. Stand establishment had not been a roblem in the broccoli and cabbage trials conducted at the same site. The dryland site in Nipawin produced a complete stand, while the adjacent irrigated site produced a poor stand. The dryland site was seeded relatively deep moisture, while the irrigated section was seeded shallow as recommended for cauliflower. The delay in vailability of irrigation in Nipawin may have contributed to the poor stand under irrigation. Large site to site variability obscured the cultivar differences in % stand. Early Dawn produced an excellent stand at all sites, while Cashmere, Incline and Yukon produced only 60% stand on average (Table CAUL-1997-1).

Time to 50% Harvest

he cauliflower crop matured most rapidly in Saskatoon, while the remaining sites had similar time to maturity haracteristics (Table CAUL-1997-1). The rapid maturity in Saskatoon likely reflects the high degree of maintenance directed to this site. The cultivars were relatively similar in time to maturity except for Incline which lagged two veeks behind the others (Table CAUL-1997-1).

Yields

ields at all sites were far in excess of average reported for AB (9.4 t/ha). Yields on dryland in Nipawin were significantly lower than the other sites (Table CAUL-1997-1). The only statistically significant difference in the ields of the cultivars tested was that the highest yielding line (Minuteman) was statistically superior to the lowest ielding line (Cashmere).

Head Characteristics

The irrigated and dryland plots in Nipawin had fewer heads graded out due to hollowstem or interleafing that in Saskatoon or Outlook (Table CAUL-1997-1). The heads in Outlook were substantially larger than the other sites - his likely reflects the fact that the stand was poor in Outlook. Head size in cauliflower increases with available space.

Serrano had an unusually high portion of heads with hollowstems while Cashmere had a high proportion of heads graded out due to interleafing.

RESULTS for 1998

The results obtained for the cauliflower trial in 1998 are outlined in table CAUL-1998-1. Data for the individual trial sites are presented in Appendices CAUL - 1998-A, B, C, and D.

Table CAUL-1998-1. **Stand, yield and head quality characteristics for Cauliflower grown at several sites in Saskatchewan in 1998.**

					Head Characteristics			
	% Stand	T50	Yield (t/ha)	% Harvest	Head Wt. (kg)	% Hollow	% Interleaf	Diam. (cm)
Concert	74	258	17.9	70	0.95	2	3	16
Fremont	78	249	20.2	72	1.01	5	1	17
Incline	79	260	18.3	68	1.01	12	6	18
Minuteman	100	244	22.4	85	0.76	0	3	16
Rushmore	92	245	22.5	81	0.89	3	3	16
Mean	*85*	*251*	*20.2*	*75*	*0.92*	*4*	*3*	*17*
LSD	**29**	**8**	**10.5**	**20**	**0.29**	**9**	**5**	**3**
Nipawin Dryland	100	255	14.3	62	0.88	4	1	15
Nipawin Irrigated	69	251	18.6	85	1.07	12	2	17
Outlook	77	250	20.6	62	0.90	1	2	17
Saskatoon	85	248	27.4	93	0.84	1	6	17
LSD	**26**	**7**	**9.4**	**18**	**0.26**	**8**	**5**	**2**
Transplant	100	229	23.5	98	0.95	5	4	18
Direct Seeded	63	272	17.0	52	0.90	3	1	16
LSD	**18**	**5**	**6.6**	**12**	**0.18**	**5**	**3**	**1**

Stand establishment

Stand establishment is notoriously difficult in direct seeded cauliflower as the emerging seedlings are small, slow growing and prone to drought and attack by flea beetles. All test plots were overseeded by 50% in anticipation of problems with stand establishment. Stand establishment was reasonably successful at all sites - with the dryland site in Nipawin producing the most complete stand. Similar results were obtained in the 1997 trial. The dryland site was seeded relatively deep to moisture, while the irrigated section was seeded shallow as recommended for cauliflower.

The delay in availability of irrigation in Nipawin may have contributed to the poor stand under irrigation. Large site x site variability obscured the cultivar differences in % stand. Minuteman produced an excellent stand at all sites (Table CAUL-1998-1). Transplanting the cauliflower crop resulted in a very complete stand relative to direct seeding.

Time to 50% Harvest

The cauliflower crop matured at a similar rate on average at all the test sites (Table CAUL-1998-1). Minuteman and Rushmore were relatively early to mature while Concert and Incline were very slow to mature (Table CAUL-1992-1). The transplanted crop matured a full month earlier than the direct seeded crop.

Yields

Yields at all sites were far in excess of average reported for AB (9.4 t/ha). Yields on dryland in Nipawin were significantly lower than the more intensively irrigated Outlook and Saskatoon sites (Table CAUL-1998-1). There were no significant differences between cultivars in terms of their total yields. Transplanting produced a marginal increase in yields over direct seeding.

Head Characteristics

The irrigated plot in Nipawin had more heads graded out due to hollowstem than the other sites. Hollowstem is caused by excessively rapid growth. It is noteworthy that the irrigated site in Nipawin also had a relatively poor stand - large gaps between plants can promote rapid growth. Incline showed excessively high amounts of hollowstem. Transplanting had little effect on head quality.

RESULTS for 1999

The results obtained for the cauliflower trial in 1999 are outlined in table CAUL-1999-1. Data for the individual trial sites are presented in Appendices CAUL - 1999-A, B, C, and D.

Table CAUL-1999-1. **Stand, yield and head quality characteristics for Cauliflower grown at several sites in Saskatchewan in 1999.**

					Head Characteristics				
	% Stand	T50	Yield (t/ha)	% Harvest	Head Wt. (kg)	% Hollow	% Interleaf	Diam. (cm)	Bead Color
Concert	77	248	17.9	82	1.49	0	14	17	2.1
Fremont	95	240	23.2	94	1.06	17	6	17	2.1
Minuteman	100	237	24.5	87	1.14	3	4	19	2.8
Pathfinder	78	222	13.2	99	0.71	1	10	18	3.0
Rushmore	100	233	28.1	96	1.17	2	4	19	2.9
Sierra	77	252	16.6	81	1.03	2	2	17	2.5
Mean	*88*	*239*	*20.6*	*90*	*1.10*	*4*	*7*	*18*	*2.6*
LSD	**31**	**26**	**10.1**	**18**	**0.53**	**7**	**11**	**3**	**0.9**
Nipawin Dryland	88	251	18.1	79	1.29	4	7	17	2.1
Nipawin Irrigated	91	234	29.9	93	1.41	6	7	20	2.7
Outlook	72	237	14.2	90	0.90	2	7	10	2.8
Saskatoon	100	232	19.9	97	0.80	5	7	16	2.6
LSD	**25**	**21**	**7.7**	**15**	**0.41**	**7**	**10**	**2**	**0.7**
Transplant	75	218	22.4	100	1.27	5	6	19	2.7
Direct Seeded	100	260	18.7	79	0.94	4	8	16	2.4
LSD	**16**	**9**	**6.2**	**9**	**0.31**	**5**	**6**	**2**	**0.5**

tand establishment

Stand establishment is notoriously difficult in direct seeded cauliflower as the emerging seedlings are small, slow rowing and prone to drought and attack by flea beetles. All test plots were overseeded by 50% in anticipation of roblems with stand establishment. Stand establishment was reasonably successful at all sites in all three test seasons. Large site to site variability obscured the cultivar differences in % stand. Minuteman and Rushmore roduced an excellent stand at all sites (Table CAUL-1999-1). Transplanting the cauliflower crop resulted in a less omplete stand than direct seeding. A similar treatment response was observed in the cabbage trial in 1999. It suggests that conditions during the spring of 1999 were more conducive to the establishment of a direct seeded than a transplanted crop.

Time to 50% Harvest and Extent of Harvest

The cauliflower crop matured at a similar rate on average at all the three of the irrigated sites but maturity was delayed at the dryland site (Table CAUL-1999-1). Less than 80% of the crop reached harvestable size at the dryland site, while over 90% of the crop was harvestable when the site was irrigated. The cv. Pathfinder tested for the first ime in 1999 was exceptionally early. Minuteman and Rushmore were relatively early to mature while Concert and Sierra were very slow to mature and many head were still left in the field at the end of the growing season (Table CAUL-1999-1). The transplanted crop matured more than a full month earlier than the direct seeded crop. Virtually all of the transplanted crop matured prior to the end of the trial period, while on average only 80% of the direct seeded crop reached marketable size within the available growing season.

Yields

Yields at all sites were far in excess of average reported for AB (9.4 t/ha). Yields under irrigation in Nipawin were significantly higher than any of the other test sites (Table CAUL-1999-1). Rushmore, Minuteman and Fremont produced exceptionally high yields while Pathfinder was relatively low yielding. Transplanting produced only a marginal increase in yields over direct seeding.

Head Characteristics

The frequency of defects such as hollowstem and interleafing were comparable at all of the test sites in the 1999 trial. The average head size was substantially larger at the Nipawin site than elsewhere. The distance to the Nipawin site precluded anything beyond weekly visits. Rapidly growing heads of cauliflower can oversize over the course of a week. Fremont had a relatively high incidence of hollowstem, while Rushmore was uniformly free of defects. Transplanting had little effect on head quality but tended to increase the average size and weight of the head. Color of the bead was slightly poorer (more yellow) under dryland conditions than when the crop was irrigated. Drought may have restricted the leaf growth required to shade the heads and keep them very white.

Summary for Cauliflower

This trial illustrates some of the challenges and some of the opportunities facing growers interested in vegetable crop production in Saskatchewan. Cauliflower is notoriously difficult to establish in the field. The seedlings are slow growing, and drone to drought stress and insect damage. However, this trial demonstrated that adequate stands could be produced even with limited seedbed preparation. Irrigation seemed to hinder rather than enhance germination of the cauliflower. Selection of cultivars with good seedling vigor appears crucial to production of a direct-seeded cauliflower crop. The slow developing seedlings must also be safeguarded against insects such as flea beetles. The results from the 1998 and 1999 trials suggest that transplants may provide a number of advantages in cauliflower

production. The crop is of sufficient value to justify the added expense and the savings in seed cost may be substantial. There is also a premium available for high quality cauliflower on the early market. Transplanted crops were a full month earlier than when the crop was established directly from seed. This difference in the rate of crop development would be particularly important when a premium is paid for early produce or when the growing season is limited in length. Uniform maturity of cauliflower is also desirable from the perspective of ease of harvest, but having the entire crop come off in a short period causes problems with consistency of supply. One option is to plant cultivars with differing rates of development. This study indicates that a range of maturity rates was available within adapted cultivars. However, none of the higher yielding cultivars were particularly early. The earlier cultivars are either not self blanching or lack other quality aspects. Yields at all sites were excellent, however abundant moisture was required for optimal yields.

Project Related Expenditures

Summer Staff

1997 - Lyle Retsalff - full time summer assistant
1998 - Rob Spencer - full time summer assistant
1999 - Corey Walcer - full time summer assistant

Capital Expenditures - nil

Project related Extension Activities

1) **Presentations - results were presented at the following meetings;**
Nipawin Vegetable growers - March 1998, 1999 and 2000
Saskatchewan Vegetable Growers - February 1999 and March 2000
AFIF Project Review - February 2000

2) **Tours**
SIDC - Annual Field Day (August 1997, 1998 and 1999)
Nipawin Vegetable Growers Field Tour - August 1997, 1998 and 1999
SVGA Annual Field tour - (August 1998)

3) **Reports**
Results were included in;
1997 and 1998 Review of Vegetable Crop Research at the University of Saskatchewan
1997 and 1998 Review of Research at Saskatchewan Irrigation Development Centre

Appendices

CAR-A **Yields and quality characteristics of carrot cultivars in Outlook - 1997**

	Harvest 1		Harvest 2			Harvest 1			Harvest 2	
	Total	Mkt.	Total	Mkt.	Taste 1	CWID 1	Leng. 1	WID 1	CWID 2	Leng
Presto	78.1a	44.7a	100.4a	49.1a	3.0ab	0.8d	12.4cd	2.7bcd	0.8b	12.5
Kamaran	61.1b	34.9ab	93.6abc	43.8ab	4.5a	1.2abc	13.0bcd	2.5abcd	1.4a	14.1c
Healthmaster	51.1bc	29.4bc	83.7cd	29.4c	3.0ab	1.5a	14.4abcd	2.5abc	1.5a	15.0bc
Earlibird Nantes	37.4d	19.3c	79.1cd	28.3c	3.3ab	1.3ab	12.8bcd	2.9a	1.2ab	12.7
Bolero	56.1bc	26.8bc	100.7a	35.8abc	3.0ab	1.1bcd	11.7d	2.3bcd	1.2ab	13.3d
Choctaw	47.3cd	27.2bc	75.0d	32.0bc	1.5	1.0bcd	15.4abc	2.2cd	1.2ab	15.9ab
Carobest	48.1cd	24.4bc	86.3abcd	38.5abc	2.0b	0.9cd	16.1a	2.1d	1.2ab	17.6
Cheyenne	53.6bc	30.5bc	85.2bcd	38.9abc	4.3a	1.1bcd	16.6a	2.4bcd	1.5a	14.1c
Caropak	43.3cd	24.8bc	73.1d	33.5bc	2.8ab	1.1bcd	15.7ab	2.4bcd	1.3a	16.5ab
Eagle	63.7b	31.7bc	99.1ab	47.4a	3.5ab	1.3ab	13.8abcd	2.6ab		14.8bc

Values within columns followed by the same letter are not significantly different.

CAR-B **Yields and quality characteristics of carrot cultivars in Nipawin under irrigation - 1997**

	Harvest 1		Harvest 2		Harvest 1			Harvest 2		
	Total	Mkt.	Total	Mkt.	CWID 1	Leng. 1	WID 1	CWID 2	Leng. 2	WID 2
Presto	24.1a	12.2a	45.9a	15.5ab	1.3ab	15.3a	2.6a	1.1c	15.7c	2.9b
Kamaran	18.6a	11.8a	43.7a	15.0ab	1.4ab	16.2a	2.6a	1.5a	16.2c	3.4ab
HM	10.6a	5.8b	26.6ab	9.3abc	1.4ab	15.4a	2.5a	1.6a	16.1c	3.4a
EBN	8.4a	3.5b	23.7ab	11.2abc	1.2ab	14.9a	2.3a	1.4a	16.3c	3.2abc
Bolero	19.9a	11.7a	46.1a	18.0a	1.4ab	15.5a	2.6a	1.5a	17.4bc	3.5a
Choctaw	24.0a	8.0ab	22.4ab	4.5c	1.4ab	19.4a	2.4a	1.3ab	18.8ab	2.8c
CB	10.5a	5.7b	29.5ab	11.7abc	1.1b	20.1a	2.2a	1.1bc	19.9a	2.8c
Cheyenne	9.5a	6.0b	17.7b	3.7c	1.4ab	19.3a	2.5a	1.5a	19.9a	3.1abc

Caropak	8.0a	3.9b	22.8ab	9.5abc	1.1ab	20.0a	2.0a	1.4a	20.0a	3.1abc
Eagle	9.3a	5.8b	20.6ab	7.1bc	1.6a	19.4a	2.6a	1.5a	18.0abc	3.2abc

Values within columns followed by the same letter are not significantly different.

CAR-C **Yields and quality characteristics of carrot cultivars in Nipawin under rainfed conditions - 1997**

	Harvest 1		Harvest 2		Harvest 1			Harvest 2		
	Total	Mkt.	Total	Mkt.	CWID 1	Leng. 1	WID 1	CWID 2	Leng. 2	WID 2
Presto	33.7a	16.5a	61.7a	14.6ab	1.0ab	14.8c	2.5ab	1.0b	14.3c	2.7ab
Kamaran	27.8ab	15.9a	56.2ab	21.4ab	1.2ab	16.1bc	2.5ab	1.3ab	15.5bc	3.0ab
Healthmaster	23.8bc	17.0a	55.1ab	31.0a	1.3a	15.4c	2.5a	1.4a	14.2c	3.1a
Earlibird Nantes	20.8bcd	14.3ab	45.3abc	16.3ab	1.0ab	15.0c	2.3abc	1.2ab	15.8abc	3.0ab
Bolero	20.7bcd	14.6ab	42.1bc	25.8ab	1.2ab	16.7bc	2.4abc	1.2ab	16.3abc	2.9ab
Choctaw	19.9bcd	12.8ab	46.3abc	12.9ab	1.3ab	19.9ab	2.4abc	1.3ab	18.7ab	2.8ab
Carobest	19.2cd	12.6ab	41.7bc	12.6ab	1.0b	19.6ab	2.1c	1.0b	17.5abc	2.4b
Cheyenne	16.4ecd	9.9ab	43.1bc	16.7ab	1.1ab	22.9a	2.3abc	1.3ab	19.5a	2.9ab
Caropak	14.1ed	8.0ab	36.1c	9.9b	1.0b	17.7bc	2.2bc	1.1ab	18.4ab	2.7ab
Eagle	9.6	4.1b	34.3c	11.3b	1.3a	19.7ab	2.4abc	1.3ab	17.9abc	2.9ab

Values within each column followed by the same letter are not significantly different

CAB-A. **Stand, growth rates and yields for cabbage - Nipawin site.**

	Stand %	Date of 50% Harvest	Final Harvest %	Yield (t/ha)	Head Density	Head Wt (kg)
Direct Seeded/Irrigated						
Balbro	100 $_{a}$	Aug 29	100 $_{a}$	68.7 $_{a}$	2.9 $_{a\,b}$	1.7 bc
Bartolo	87 $_{bc}$	Oct 17	50 $_{c}$	46.1	3.5 $_{a}$	1.8 bc
Bravo	93 $_{b}$	Sept 14	85 $_{a\,b}$	62.4 $_{a\,bc}$	2.9 $_{a\,b}$	2.2 b
Cecile	97 $_{b}$	Sept 10	68 $_{b\,c}$	65.7 $_{a\,b}$	3.5 $_{a}$	2.3 b
Dynamo	100 $_{a}$	Aug 31	100 $_{a}$	55.1 $_{c\,d}$	3.5 $_{a}$	1.2 c
Hinova	66 $_{c}$	Oct 5	73 $_{a\,bc}$	58.6 $_{bc}$	2.8 $_{a\,b}$	3.1 $_{a}$
Lennox	77 $_{b\,c}$	Oct 9	68 $_{bc}$	49.7 $_{d\,e}$	3.0ab	2.2 b
Masada	17 $_{d}$	Oct 17	17 $_{d}$	15.8 $_{f}$	2.2 $_{b}$	3.4 $_{a}$
Transplanted/Irrigated						
Balbro	100 $_{a}$	Aug 21 $_{c}$	100 $_{a}$	77.3 $_{a}$	3.7 $_{bc}$	1.7 de
Bartolo	80 $_{b}$	Sept 22 $_{b}$	60 $_{b}$	54.9 $_{b}$	4.2 $_{a\,b}$	2.3 bc
Bravo	100 $_{a}$	Aug 26 $_{c}$	100 $_{a}$	73.3 $_{a}$	3.4 $_{c}$	2.0 cd
Cecile	100 $_{a}$	Aug 26 $_{c}$	97 $_{a}$	80.8 $_{a}$	4.8 $_{a}$	2.4 bc
Dynamo	100 $_{a}$	Aug 19 $_{c}$	100 $_{a}$	53.9 $_{b}$	4.9 $_{a}$	1.2 c
Hinova	100 $_{a}$	Sept 3 $_{b\,c}$	93 $_{a}$	79.9 $_{a}$	4.6 $_{a}$	2.6 b
Lennox	100 $_{a}$	Sept 22 $_{b}$	88 $_{a}$	80.5 $_{a}$	4.6 $_{a}$	2.4 bc
Masada	66 $_{c}$	Oct 17 $_{a}$	58 $_{b}$	72.5 $_{a}$	3.3 $_{c}$	3.6 a

Values within each column followed by the same letter are not significantly different

CAB-A (continued). Stand, growth rates and yields for cabbage - Nipawin site

Direct Seeded/Dryland

	Stand %	Date of 50% Harvest	Final Harvest %	Yield (t/ha)	Head Density	Head Wt (kg)
Balbro	84 $_{b}$	Aug 26 $_{d}$	100 $_{a}$	42.3 $_{bc}$	3.4 $_{c}$	1.8 $_{b c}$
Bartolo	87 $_{b}$	Oct 17 $_{a}$	32 $_{b}$	45.4 $_{abc}$	3.4 $_{c}$	1.7 $_{b c}$
Bravo	70 $_{b}$	Sept 10 $_{c}$	98 $_{a}$	65.8 $_{ab}$	2.4 $_{c}$	3.3 $_{a}$
Cecile	84 $_{b}$	Sept 10 $_{c}$	85 $_{a}$	66.8 $_{ab}$	3.4 $_{c}$	2.8 $_{a b}$
Dynamo	100 $_{a}$	Aug 28 $_{d}$	100 $_{a}$	38.6 $_{c}$	4.8 $_{a}$	0.8 $_{c}$
Hinova	---			---		
Lennox	84 $_{b}$	Sept 23 $_{b}$	75 $_{ab}$	71.8 $_{a}$	3.3 $_{c}$	3.0 $_{a}$
Masada	56 $_{b}$	Oct 17 $_{a}$	70 $_{b}$	65.7 $_{ab}$	3.2 $_{c}$	3.9 $_{a}$
Transplanted/Dryland						
Balbro	100 $_{a}$	Aug 19 $_{d}$	100 $_{a}$	71.3 $_{b}$	3.5 $_{bc}$	2.0 $_{bc}$
Bartolo	100 $_{a}$	Sept 23 $_{ab}$	80 $_{a}$	59.3 $_{b}$	4.1 $_{ab}$	1.8 $_{c}$
Bravo	100 $_{a}$	Sept 3 $_{c}$	100 $_{a}$	70.0 $_{b}$	2.4 $_{d}$	2.1 $_{bc}$
Cecile	100 $_{a}$	Sept 3 $_{c}$	98 $_{a}$	83.4 $_{c}$	4.3 $_{ab}$	2.2 $_{bc}$
Dynamo	100 $_{a}$	Aug 23 $_{d}$	100 $_{a}$	42.4 $_{c}$	4.8 $_{a}$	1.1 d
Hinova	100 $_{a}$	Sept 18 $_{b}$	86 $_{a}$	66.1 $_{b}$	4.2 $_{ab}$	2.2 $_{bc}$
Lennox	100 $_{a}$	Sept 23 $_{ab}$	82 $_{a}$	68.3 $_{b}$	4.2 $_{ab}$	2.2 $_{a}$
Masada	47 $_{b}$	Oct 1 $_{a}$	32 $_{b}$	45.6 $_{c}$	3.06 $_{cd}$	3.2 $_{a}$

Values within each column followed by the same letter are not significantly different

CAB-B. Stand, growth rates, yields and head characteristics for Cabbage - Outlook site.

Direct Seeded

	Stand %	Date of 50% Harvest	Final Harvest %	Yield (t/ha)	Head Density	Head Wt (kg)
Balbro	100 $_{a}$	Aug 28 $_{b}$	100 $_{a}$	67.3 $_{abc}$	4.1 $_{bc}$	1.8 $_{b}$
Bartolo	66 $_{b}$	Oct 10 $_{a}$	100 $_{a}$	39.2 $_{c}$	3.6 $_{cd}$	2.1 $_{ab}$
Bravo	100 $_{a}$	Sept 11 $_{b}$	100 $_{a}$			
Cecile	100 $_{a}$	Sept 11 $_{a}$	100 $_{a}$	89.0 $_{a}$	3.9 $_{bc}$	2.8 $_{a}$
Dynamo	100 $_{a}$	Aug 28 $_{a}$	100 $_{a}$	40.9 $_{c}$	4.8 $_{a}$	1.1 $_{c}$
Hinova	70 b	Oct 20 $_{a}$	100 $_{a}$	57.8 $_{abc}$	3.2 $_{dc}$	2.8 $_{a}$
Lennox	83 b	Oct 20 $_{a}$	100 $_{a}$	52.4 $_{bc}$	4.2 $_{b}$	2.3 $_{ab}$
Masada	83 b	Oct 20 $_{a}$	43 b	57.2 $_{abc}$	2.5 $_{f}$	2.3 $_{ab}$

Values within each column followed by the same letter are not significantly different

CAB-C. Stand, growth rates and yields for cabbage - Saskatoon site

Direct Seeded

	Stand %	Date of 50% Harvest	Final Harvest %	Yield (t/ha)	Head Density	Head Wt (kg)
Balbro	100	Aug 22	100	61.5	3.5	1.6
Bartolo	100	Aug 30	90	65.2	4.8	1.7
Bravo	100	Aug 29	100	76.1	3.1	1.6
Cecile	100	Aug 29	70	44.6	4.3	1.5
Dynamo	100	Aug 22	100	42.9	4.9	1.2
Hinova	100	Aug 29	80	57.8	3.6	1.8
Lennox	96	Sept 21	78	48.2	4.1	1.7
Masada	77	Oct 14	56	44.8	2.6	1.9

BRO-A **Stands, yields and quality characteristics for Broccoli**

	% Stand	Date of 50% Harvest	Yield (t/ha)	% Hollow	Interleaf (%)	Head Diameter (cm)
				Outlook		
Arcadia	100	36034	25	18	17	18.9
Early Dividend	90	36014	18	38	51	17.2
Emerald City	100	36024	34	7	8	16.1
Everest	100	36014	23	10	8	17.4
Marathon	100	36034	47	43	18	22.3
Patriot	100	36034	44	15	20	20.8
				Saskatoon		
Arcadia	87	36027	28	19	50	18.8
Early Dividend	78	36000	9.2	27	15	13.2
Emerald City	80	36027	25.1	2	33	16.9
Everest	71	36011	10.6	6	30	12.2
Marathon	87	36035	29.4	24	63	20.3
Patriot	75	36035	22.9	11	70	19.9
				Nipawin - Irrigated		
Arcadia	82	Sept 4	14.8	15	0	17.9
Early Dividend	80	36012	13	21	5	15.6
Emerald City	88	36032	15	22	14	18.7
Everest	86	36019	16.5	17	25	19.5
Marathon	100	Sept 4	17.9	27	9	18.1
Patriot	75	Sept 4	12.9	24	19	17.2

				Nipawin - Dryland		
Arcadia	70	Sept 4	8.6	2	6	17.3
Early Dividend	62	36025	5.3	0	0	13.9
Emerald City	85	Sept 4	10.6	0	2	14.8
Everest	78	36025	8.3	0	0	17.6
Marathon	52	Sept 11	8	3	3	14.8
Patriot	54	Sept 11	7.2	5	8	12.7

CAUL-A **Stand, yield and quality data for Cauliflower**

	% Stand	Date of 50% Harvest	Yield (t/ha)	% Hollow	Interleaf (%)	Head Diameter (cm)
Cashmere	40	Sept 17	17.3	7	29	17.7
Early Dawn	100	Sept 4	31.7	0	2	18.5
Incline	60	36068	31.8	18	14	18.6
Minuteman	100	36032	38.9	5	10	19.3
Rushmore	78	Sept 11	29.1	29	3	17.4
Serrano	58	Sept 11	28.9	8	14	20.6
Yukon	28	Sept 17	18.7	15	0	18.8
			Saskatoon			
Cashmere	94	36020	26.7	15	26	12.3
Early Dawn	100	Aug 5	25.6	0	3	13.6
Incline	100	36035	28.8	11	5	10.6
Minuteman	100	36028	22.4	0	8	12.8
Rushmore	100	36028	25.3	0	10	13.6
Serrano	82	36028	21.5	35	3	21.3
Yukon	80	36028	27.2	21	8	17.9
			Nipawin - Irrigated			
Cashmere	70	Sept 3	22.1	0	0	13.4
Early Dawn	100	Sept 3	24.5	0	0	14.1
Incline	76	Sept 23	23.3	3	0	15.2
Minuteman	76	Sept 3	25.1	3	0	17.2
Rushmore	92	Sept 3	23.2	0	0	16.1
Serrano	77	Sept 10	23.2	0	0	11.6

Yukon	72	Sept 10	21.9	0	0	15.2
			Nipawin-Dryland			
Cashmere	100	Sept 3	13.6	0	2	14.6
Early Dawn	100	36032	18	0	0	15.9
Incline	68	36070	10.8	0	0	11.4
Minuteman	100	36032	276.3	0	0	16.7
Rushmore	100	Sept 3	23.9	0	4	16.4
Serrano	100	Sept 10	19	0	0	14.9
Yukon	100	Sept 10	21.3	0	0	11.6